Appendix D.5
Surface Water Sampling Results and Analysis

PDI Evaluation Report

Portland Harbor Pre-Remedial Design Investigation and Baseline Sampling

Portland Harbor Superfund Site
Portland, Oregon

AECOM Project Number: 60566335
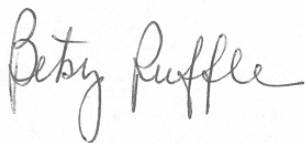Geosyntec Project Number: PNG0767

June 17, 2019

Prepared by:

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AECOM

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

June 17, 2019

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Betsy Ruffle   Date
PDI Project Coordinator
AECOM Technical Services

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ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
AECOM	AECOM Technical Services
AQI	air quality index
BaP	benzo(a)pyrene
cfs	cubic feet per second
COC	contaminant of concern
CR	change request
CUL	cleanup level
CSM	Conceptual Site Model
DDx	dichlorodiphenyltrichloroethane and its derivatives
DOC	dissolved organic carbon
D/U Reach	Downtown/Upriver Reach
E	east bank
EPA	United States Environmental Protection Agency
fDOM	fluorescence of dissolved organic matter
FSR	Field Sampling Report
Geosyntec	Geosyntec Consultants, Inc.
L	liter
M	mid-channel
mg/L	milligrams per liter
NB	near bottom
ng/L	nanograms per liter
NS	near surface
NTU	nephelometric turbidity unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PeCDD	pentachlorodibenzo-p-dioxin
PDI	pre-remedial design investigation
PeCDF	pentachlorobibenzofuran
pg/L	picograms per liter
PM$_{2.5}$	particle matter smaller than 2.5 micrometers in air quality reporting
Pre-RD AOC Group	Pre-Remedial Design Agreement and Order on Consent Group
RI	remedial investigation

RM	river mile
ROD	Record of Decision
SMA	sediment management area
Site	Portland Harbor Superfund Site
TCDD	tetrachlorodibenzo-p-dioxin
TDS	total dissolved solids
TEQ	toxicity equivalence
TOC	total organic carbon
TSS	total suspended solids
USGS	United States Geological Survey
W	west bank

1.   INTRODUCTION

The Pre-Remedial Design Agreement and Order on Consent Group (Pre-RD AOC Group) for the Portland Harbor Superfund Site (Site) in Portland, Oregon, has developed and implemented a Pre-Remedial Design Investigation (PDI) for the Site. The Site Record of Decision (ROD) (United States Environmental Protection Agency [EPA] 2017) described a post-ROD sampling effort for the Site to delineate and better refine the sediment management area (SMA) footprints, refine the Conceptual Site Model (CSM) determine baseline conditions, and support remedial design. The PDI studies were conducted by the Pre-RD AOC Group pursuant to a PDI Work Plan (Geosyntec Consultants, Inc. [Geosyntec] 2017) as a foundational step to update current conditions since collection of data during the remedial investigation (RI)/feasibility study.

The Site is located on a 10-mile stretch of the lower Willamette River from river mile (RM) 1.9 upstream to RM 11.8. The Site covers approximately 2,200 acres[1] of an active industrial, commercial, and urbanized harbor and is located immediately downstream of the urban downtown. There are two reaches located immediately upstream of the Site. The Downtown Reach, which includes the urbanized area of downtown Portland, is defined by EPA as extending from RM 11.8 to RM 16.6. EPA defines the Upriver Reach as extending from RM 16.6 to RM 28.4. Collectively, RM 11.8 to RM 28.4 is referred to as the Downtown/Upriver Reach (D/U Reach). Transect 7 at RM 16.2 is located in the D/U Reach at the boundary of the Downtown Reach and Upriver Reach. Transect 6 located at RM 11.8 is at the upriver boundary of the Site, at the downriver boundary of the D/U Reach. In this appendix, the data are described by RM and indicated as within the D/U Reach, as appropriate. Figures plotting by RM include a line demarcating the location of the D/U Reach boundary.

1.1   Rationale for Surface Water Sampling

This document presents the results of the PDI surface water sampling conducted for the Site. The PDI Work Plan identified the following primary objectives of the surface water sampling program (Geosyntec 2017):

- Establish baseline river conditions with synoptic data (sediment, fish tissue, surface water).

- Characterize current conditions in surface water and changes since the RI.

- Provide 2018/2019 data (also called "PDI data") to refine the CSM for remedial design purposes.

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[1] The ROD states the Site is approximately 2,190 acres and extends from RM 1.9 to RM 11.8. However, when mapped in GIS, the 2,190 acres only covers the area from RM 1.9 to 11.6 (at the end of the authorized navigation channel). The acreage from RM 1.9 up to RM 11.8 is more accurately 2,203 acres.

The PDI included surface water sampling to evaluate concentrations of contaminants of concern (COCs) under three flow scenarios (low-flow, storm-flow, and high-flow).

This report presents concentrations of COCs in surface water both within and upstream of the Site, including comparison of results with cleanup levels (CULs) established in the ROD (Table 17 of the ROD), a discussion of changes in surface water concentrations over time (i.e., compared to sampling conducted during the RI in 2006/2007), and overall observations and implications for the CSM.

2.   SUMMARY OF SURFACE WATER SAMPLING

Surface water sampling was conducted for the PDI under three distinct flow conditions: low flow, high flow, and storm flow. Events were scheduled based on two criteria: (i) river flow and storm conditions (primary criterion) as described below; and (ii) target months (secondary criterion) for consistency with historical data. Three rounds of sampling were conducted between August 2018 and February 2019 from seven in-river transects (Figure 1). High-volume XAD sampling (~400 liter [L] for low-flow and high-flow, and ~150 L for storm-flow) and peristaltic pump sampling were conducted using similar methods as the RI sampling events. Details of the PDI low-flow, storm-flow, and high-flow sampling events are provided in the Surface Water Field Sampling Report (FSR), included as Appendix B.5 to the PDI Evaluation Report. Synoptic collection of optical parameters, total algae, and fluorescence of dissolved organic matter (fDOM) during high-volume sampling is described in Exhibit A.

2.1   River Flow Conditions During Sampling

Flow conditions were monitored using the United States Geological Survey (USGS) Real Time National Weather Information System Database for the Morrison Bridge station 14211720 located at RM 12.7. Average daily flows were calculated from the gauge data, which are provided in 15-minute intervals. Annual low water levels occur during the summertime regional dry season (June to October), then flows increase during the wetter winter months (November to March). The flow regime can influence the concentration of contaminants in the water column; therefore, samples were collected under the following conditions:

- Low-flow sampling criteria were characterized as sustained daily average flows less than 20,000 cubic feet per second (cfs), and the targeted date range was July to August 2018. River flows were 5,041 to 8,697 cfs during sampling conducted from August 21 to 25, 2018 (criteria were met).

- Storm-flow sampling criteria were characterized as sustained flows ideally less than the low-flow maximum (i.e., 20,000 cfs) averaged over the month and a substantial rain event that causes an increase in river flow up to (and possibly greater than) 40,000 cfs, to capture solids that may be mobilized during these episodic events. The target sampling date range was October to December 2018. Flow in the river during the month prior to the rain event that triggered the storm-flow sampling averaged 7,800 cfs, and flows were

16,780 to 27,407 cfs during the sampling event, which occurred from November 27 to December 1, 2018.

- High-flow sampling criteria were characterized by sustained, non-storm-induced flows of greater than 50,000 cfs and a targeted sampling date range from November 2018 to February 2019. The high-flow sampling event was conducted in two phases: January 25 to 27, 2019, and February 17 and 18, 2019. In mid-January 2019, flows started to rise and were sustained above 50,000 cfs coming into the sampling event. Flows during this first phase of high-flow sampling ranged from 55,069 (January 25) to 42,281 cfs (January 27, when flows started to drop to the lower end of the target range). Change request (CR) 22 described these lower flow conditions during the high-flow event; it was approved by EPA (see Section 2.7 of the FSR in Appendix B.5). Flows started to rise again on February 12 and were sustained above 50,000 cfs through the second phase of the high-flow event, with a range over the February sampling period from 55,781 to 52,897 cfs.

2.2   Transect-Composited Sampling

Samples in the PDI program were collected from seven transects (Figure 1):

- Transect 1: RM 1.8 at the downstream boundary of the Site

- Transect 2: Downstream boundary of the Site at Multnomah Channel; entrance to channel is near RM 3

- Transect 3: RM 4

- Transect 4: RM 7

- Transect 5: RM 8.8

- Transect 6: RM 11.8, upstream, at the Site/Downtown Reach boundary

- Transect 7: RM 16.2, upstream, near the Downtown Reach/Upstream Reach boundary

Composite samples were collected by sampling equal volumes from three stations (east shore, middle of the navigation channel, and west shore) along each transect and at up to three depths per station: upper depth (3 feet below water surface), near bottom (3 feet above sediment surface), and middle (equal distance between upper and bottom). These subsamples, up to nine depending on river depth, were composited for chemical testing. Samples for dioxin/furans, polychlorinated biphenyls (PCBs), organochlorine pesticides, and polycyclic aromatic hydrocarbons (PAHs) were sampled using a high-volume method; all other analytes were collected using a peristaltic pump to fill a carboy with an equal volume from each sub-location across each transect. Composited samples were collected at each surface water transect for analysis of all analytes except ethylbenzene; samples for ethylbenzene were collected as discrete samples from the bottom depth at the three stations across each transect. Standard field parameters, as well as total algae and fDOM (optical parameters), were recorded with a YSI instrument during high-volume sample collection, as described in CR-15 (see Section 2.7 of the

FSR in Appendix B-5). The measured optical parameters were related to measured COC and/or total suspended solids (TSS) concentrations, as described in Exhibit A to develop a predictive relationship that can be applied to continuous optical measurements at the Morrison Street Bridge USGS gauging station.

All sampling was performed according to the Surface Water Field Sampling Plan (AECOM Technical Services [AECOM] and Geosyntec 2018a). Details of the sampling are provided in Appendix B.5 to the PDI Evaluation Report (Surface Water FSR).

3. SUMMARY OF PDI SURFACE WATER DATA RESULTS

This section presents a summary of the surface water data collected during the PDI sampling events in 2018 and 2019. Data for all analytes (measured either using peristaltic pump or high-volume XAD methods; see the FSR in Appendix B-5 for methodology details) are presented as analyte groups (e.g., pesticides, metals, etc.) in scatter plots by RM. For the samples collected using high-volume methods, dissolved fraction and particulate fraction samples were analyzed separately; these fractions were combined (summed) to calculate a whole water concentration. Details on the summations are presented in Exhibit B. Tables 1 through 3 provide summary statistics for whole water analytes for the PDI low-flow, storm-flow, and high-flow events, respectively. The summary statistics for all analytes, including the particulate and dissolved phase fractions from the high-volume samples, are provided in Appendix D.9 to this PDI Evaluation Report. Exhibits C and D contain scatter plots of the concentrations of COCs as a function of discharge (flow) in the Willamette River and as a function of TSS, respectively. For those COCs that were analyzed using high-volume methods, the three fractions (dissolved,[2] particulate, and total) are presented in bar charts in Exhibit E. Appendix A to this PDI Evaluation Report provides tables of the surface water data, as well as the laboratory reports for all the sampling events.

Results are presented for all COCs with CULs for surface water identified in Table 17 of the ROD. Several COCs were not detected, had low frequencies of detection, and/or were consistently under the CULs, and are discussed briefly in Section 3.4.

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[2] The definition of "dissolved" fraction depends on the analyte and sampling method. For metals, solids, and organic carbon, the dissolved fraction is the mass of COC passing through the 0.45-micron inline filter. For the organic COCs analyzed using high-volume sampling methods, "dissolved" fraction refers to the mass of COC that passes through the 0.5-micron flat filter in the field and is sorbed onto the XAD resin. Reible et al. (2018) demonstrated that a substantial portion of organic contaminants, including PAHs and PCBs, may be retained in a sample filtered to 0.7 microns, and refers to this dissolved fraction as "operationally dissolved."

3.1 Physical Parameters

Solids

Total dissolved solids (TDS) (Figure 2) and TSS (Figure 3) concentrations varied among the upstream and Site transects. During the low-flow event, concentrations of TDS were higher in the Multnomah Channel and RM 1.8 than other locations. The maximum concentration of TDS during the storm-flow event was detected at RM 4. TSS was highest at RM 4 during the low-flow event. Storm-flow event TSS was consistent among detected samples but had a lower frequency of detection (only three of seven samples were detected). TSS in the high-flow event was highest at RM 8.8, decreasing with distance downstream. TDS did not vary with flow (Exhibit C, Figure C-1), but TSS was lower during storm flows (Figure C-2) than during the low-flow or high-flow event. During the RI sampling in 2006, TSS concentrations were lower during the storm-flow event (3 to 6 milligrams per liter [mg/L] with an average of 4.2 mg/L) than the low-flow event (3 to 12 mg/L with an average of 7.6 mg/L). This finding is inconsistent with the CSM, which suggests a positive correlation between TSS concentrations and flow rate in the lower Willamette River. The storm-flow event is not indicative of a sustained high-flow that mobilizes bedded sediments and increases TSS. The storm-flow events were not high-intensity storms, and less rain fell during the 2018 storm-flow event than in 2006. Turbidity during the storm-flow event (0.61 to 6.06 nephelometric turbidity units [NTU] with an average of 2.09 NTU) was lower than during the low-flow event (2.13 to 104.9 NTU with an average of 6.4 NTU) (see Appendix B.5, Tables 2a and 2b).

Organic Carbon

Organic carbon in suspended sediment and the dissolved phase is quantified by total organic carbon (TOC) and dissolved organic carbon (DOC), respectively. Both were higher in the upstream samples than within the Site during the low-flow sampling, and lower in the upstream transects during high-flow sampling (Figures 4 and 5). The location of higher TOC varied in storm-flow event samples, with highest concentrations at RM 7 and RM 11.8. DOC and TOC were highest during the high-flow sampling event at transect RM 7 and in the Multnomah Channel. Overall, both DOC (Figure C-3) and TOC (Figure C-4) were higher in samples from the low-flow event than the storm-flow event, but DOC and TOC in the high-flow event samples were higher than for the low-flow or storm-flow event.

3.2 Organic COCs

Organic constituents (PAHs, pesticides, PCBs, and dioxins/furans) discussed in this section were analyzed using the high-volume sampling techniques. Unless indicated, discussion of concentrations and patterns, including relationship to flow (Exhibit C) or TSS (Exhibit D), covers whole water concentrations (i.e., the calculated sum of dissolved phase and particulate phase concentrations). The contributions of dissolved and particulate phase concentrations relative to the whole water concentrations are presented in Exhibit E.

Polycyclic Aromatic Hydrocarbons

PAHs are presented as benzo(a)pyrene (BaP)-toxicity equivalence (TEQ), because the ROD established a CUL in surface water for BaP-TEQ and not total PAHs. Figure 6 shows the concentrations of BaP-TEQ in low-flow, storm-flow, and high-flow samples by RM. At the upstream boundary of the Site (RM 11.8), concentrations are low (0.179 to 0.253 nanograms per liter [ng/L]) in all three events but above the CUL. Concentrations increase, especially during the low-flow event, at RM 7, RM 4, and in the Multnomah Channel. Concentrations of BaP-TEQ in surface water are highest at RM 4 under low-flow conditions and the Multnomah Channel under storm-flow and high-flow conditions. Concentrations at RM 1.8 were lower than at RM 4 in all events.

In general, concentrations of BaP-TEQ were highest during lower flows (Figure C-5). Concentrations of BaP-TEQ show a positive relationship with TSS (Exhibit D, Figure D-1), with higher concentrations associated with higher TSS; however, TSS was below the detection limit in four of the seven storm-flow event samples, which adds uncertainty to this comparison. The detection limit for TSS (2 mg/L) met the project quality objectives presented in the PDI Quality Assurance Project Plan (AECOM and Geosyntec 2018b); therefore, the relationship is considered valid. The correlation between BaP-TEQ and TSS was weak in the high-flow event samples.

The majority of BaP-TEQ in surface water samples is associated with the particulate phase (Exhibit E; Figure E-1) in all PDI samples.

Pesticides

Dichlorodiphenyltrichloroethane and its derivatives (DDx)

DDx is presented by RM in Figure 7. None of the concentrations of DDx exceeds the CUL. The samples from the upstream boundary of the Site (RM 11.8) and at RM 16.2 have lower concentrations than samples collected from within the Site in the low-flow and storm-flow events. The high-flow event concentrations at RM 16.2 (0.446 ng/L) were almost 10 times higher than during the other events and were similar to the highest concentrations measured within the Site (0.505 ng/L from the high-flow event at the Multnomah Channel). The lowest concentration was at RM 11.8 during the high-flow event. Flows had dropped below the 50,000 cfs threshold during the 2-day sampling effort at RM 11.8, which may have caused some settling of solids.

When evaluated as a function of discharge (Figure C-6), concentrations of DDx were generally higher during the low-flow event than during the storm-flow and high-flow events. TSS (Figure D-2) does not appear to be a major factor in the concentration gradient for the low-flow events, but the relation between DDx and TSS was strong in the storm-flow and high-flow events. This is reflected in the concentrations by fraction (Figure E-2), which show a very similar contribution from dissolved and particulate phases from most samples during the low-flow sampling event. In the storm-flow and high-flow events, the particulate phase contributed a

higher fraction to the whole water than dissolved, with particulate phase dominating the whole water in the high-flow event.

Aldrin

Concentrations of aldrin were much higher during the low-flow than the storm-flow event for transects within the Site. The high-flow concentrations were between low-flow and storm-flow concentrations. For the transect samples at RM 11.8 and RM 16.2, concentrations were lower than Site transects. The concentration of aldrin at RM 16.2 was higher in the high-flow event than in the storm-flow or low-flow events. Aldrin was present above the CUL during the low-flow event at the upstream boundary (RM 11.8), elevated from RM 8.8 to RM 4, then decreased in the Multnomah Channel and RM 1.8 (Figure 8). Concentrations during the storm-flow and high-flow events varied little with distance downstream. Concentrations exceeded the CUL during the storm-flow event at RM 8.8 and the Multnomah Channel and during the high-flow event at all transects except RM 11.8. Concentrations of aldrin were more variable during the low-flow event than the other events.

In general, concentrations of aldrin were higher at lower flows (Figure C-7) than during the higher flows from the storm-flow or high-flow events. Concentrations of aldrin were positively correlated in all three events with TSS (Figure D-3). This is reflected in the concentrations by fraction, where the particulate fraction is the primary contributor to whole water concentrations in most samples from the storm-flow and high-flow events. In the dissolved phase, aldrin was not detected (Figure E-3) during the storm-flow event. In the low-flow event, the dissolved phase contributed more to the whole water concentration than particulate phase at RM 4 and RM 7; concentrations in the particulate phase were below the detection limit at RM 11.8 and RM 16.2. In the high-flow event, the particulate concentration, where detected, was higher than dissolved; concentrations in the particulate phase were below detection limits at RM 11.8.

Total Chlordanes

Concentrations of total chlordanes (sum of alpha-chlordane, cis-nonachlor, trans-chlordane, trans-nonachlor and oxychlordane) were all below the CUL (Figure 9). Concentrations coming into the Site from upstream (RM 16.2 and 11.8) were lower than concentrations from samples within the Site (RM 8.8 to RM 4) for the low-flow and high-flow samples but were comparable in storm-flow event samples. Concentrations were higher at RM 7 and RM 4 for the low-flow samples, but concentrations at RM 1.8 were lower than those coming into the Site at RM 11.8. Concentrations in storm-flow samples were more variable spatially compared to the low-flow samples. In the high-flow samples, the concentration at RM 16.2 was higher than RM 7 through RM 11.8. The highest concentrations were at RM 4 and the Multnomah Channel. Concentrations of total chlordanes were higher in concentration during low flow (Figure C-8) and highest during the high flows. Total chlordanes showed a slightly positive correlation to TSS (Figure D-4) in all three events. In both the low-flow and storm-flow events, concentrations of total chlordanes were higher in the dissolved phase than the particulate phase, in particular during the low-flow event

(Figure E-4). During the high-flow event, the particulate fraction of total chlordane was the dominant fraction.

Hexachlorobenzene

Unlike the other pesticides, concentrations of hexachlorobenzene were much higher during the storm-flow and high-flow event than the low-flow event. Hexachlorobenzene was not present above the CUL during the low-flow event at the upstream Site boundary (RM 11.8) or in the D/U Reach (RM 16.2) and varied little with distance downstream, remaining below the CUL (Figure 10). During the storm-flow event, concentrations of hexachlorobenzene were at or near the CUL at RM 16.2 (in the D/U Reach) and at RM 11.8 (the upstream Site boundary), peaked at RM 8.8, and were above the CUL at RM 1.8. All concentrations of hexachlorobenzene were below the CUL in the high-flow event samples. Higher concentrations were observed with the storm-flow discharge (Figure C-9), and the lowest flows had the lowest concentrations. There was a negative correlation to TSS in the low-flow and storm-flow events, but a positive correlation in the high-flow event (Figure D-5). The relationship with TSS in the low-flow and storm-flow events is supported by the analysis of the fractions of hexachlorobenzene, which were higher in the dissolved phase than the particulate phase in samples from all events (Figure D-5), especially during the storm-flow event.

Tetrachlorodibenzo-p-dioxin (TCDD)-TEQ

All concentrations of TCDD-TEQ exceeded the ROD CUL during all flows at all locations (Figure 11). Total TCDD-TEQ comprises 17 individual dioxin/furan congeners, many of which were not detected above detection limits. The detection limits for the individual congeners from the PDI events range from 0.00763 to 0.0131 picograms per liter (pg/L) (Appendix D.9), which are higher than the CUL (0.00005 pg/L) by two orders of magnitude. During the low-flow event, the concentration of TCDD-TEQ was lower from the D/U Reach (RM 16.2) than during the storm-flow and high-flow events. Concentrations were generally similar at RM 11.8 (the upstream Site boundary) in all three events (low-flow = 0.0496 pg/L, storm-flow = 0.0562 pg/L and high-flow = 0.0508 pg/L). During the low-flow and high-flow events, concentrations increased at RM 7 and remained elevated at RM 4 and RM 1.8, whereas during the storm-flow event, concentrations did not increase until RM 4. In all events, concentrations were generally consistent downstream of RM 4 and within the Multnomah Channel.

Dioxin/furan concentrations were not correlated to discharge (Figure C-10), although concentrations in all events showed a positive, albeit weak, correlation to TSS (Figure D-6). The particulate phase dominated the total water concentrations (Figure E-6), with dissolved fraction comprising < 2% to 10.8% of the total water column concentration among the three events.

Dioxin/Furan Data Uncertainty

A large portion of the dioxin and furan congener surface water data were qualified using J, J+, or JN qualifiers during validation (see Tables 7, 8, and 9). As described in Exhibit B, these qualifiers were assigned during validation to the dissolved and particulate fractions and carried into the whole water data calculations (i.e., if a fraction value was qualified as J, the whole water was also qualified with a J). Of the dioxin and furan congeners in the dissolved phase, 29%, 10%, and 23% of data were qualified in the low-flow, storm-flow, and high-flow events, respectively. This is due to lower frequency of detection in the dissolved fraction (36%, 13%, and 29% detection, respectively, in the three events). Congeners in the particulate fraction were more often detected in the low-flow, storm-flow, and high-flow events (73%, 87%, and 76%, respectively). Qualification in the particulate fraction from these events was also higher (53%, 63%, and 51%, respectively).

The dioxin/furan analytical results for solid media (surface and subsurface sediments, sediment trap, and fish tissue samples) collected for the PDI also contain a substantial number of qualified results. The data qualifiers assigned by the laboratory and/or the project data validator include J-flagged values, indicating an "estimated" result, and JN-flagged values, indicating the analyte is tentatively identified and the result is estimated. JN-flagged values are associated with results reported by the laboratory as "estimated maximum possible concentrations." The frequency and types of laboratory- and data validator-qualified results in each dataset need to be considered carefully in determining data uses (see Appendix A).

Appendix E evaluates the uncertainty associated with qualified data for the three dioxin/furan congeners listed in the ROD as focused COCs (2,3,7,8-TCDD, 1,2,3,7,8- pentachlorodibenzo-p-dioxin [PeCDD] and 2,3,6,7,8- pentachlorobibenzofuran [PeCDF]). The appendix focuses on surface sediment; however, the approaches and considerations discussed are applicable to other matrices, including surface water and fish tissue. In summary:

- The ROD CUL and fish tissue targets for dioxins and furans are close to or below the congener detection limits. Accuracy of results close to the detection limits is reduced due to uncertainties associated with the analytical method.

- Qualified sample concentrations lead to some fundamental limitations in the use of the PDI dioxin/furan dataset, including decision-making related to remedy design and implementation at the Site.

Total PCBs

All concentrations of total PCBs exceeded the CUL. Concentrations at RM 11.8 (coming into the Site from the upstream Site boundary; 208 pg/L during low-flow event, 95.5 pg/L during storm-flow event, and 124 pg/L during the high-flow event; Figure 12) were approximately one-third the maximum concentration observed within the Site during the low-flow event (591 pg/L) and the storm-flow event (253 pg/L). During the high-flow event, the concentration of total PCBs at

RM 11.8 (124 pg/L) was approximately two-thirds the maximum concentration observed within the Site (183 pg/L at RM 7). In low-flow and storm-flow events, the concentration of total PCBs was higher farther upstream at RM 16.2 (within the D/U Reach) than at RM 11.8. However, during the high-flow event, the concentration at RM 16.2 was lower than at RM 11.8. For all events, total PCBs follow the same general pattern within the Site, with concentrations increasing at RM 8.8, then decreasing at RM 7, followed by a maximum concentration at RM 4, and concentrations in the Multnomah Channel and at RM 1.8 lower than at RM 4. Overall, the concentrations during the low-flow event were up to four times higher than concentrations in the storm-flow or high-flow event samples, indicating an inverse relationship to river discharge (Figure C-11).

There is a positive correlation between TSS and total PCBs in the low-flow event and the high-flow event, but a negative correlation for the storm-flow event (Figure D-7). Concentrations of total PCBs increased with TSS during low-flow conditions.

The dissolved phase of total PCBs dominated the whole water concentrations (Figure E-7) in the low-flow event. In the low-flow event, the dissolved phase concentrations accounted for 59% (Multnomah Channel and RM 4) to 76% (RM 16.2) of the concentrations of total PCBs in whole water. During the storm-flow event, the dissolved fraction contributed more evenly to the whole water concentrations, ranging from 38% (Multnomah Channel) to 66% (RM 4) of whole water concentrations of total PCBs. During the high-flow event, the particulate phase fraction dominated the whole water concentration in six of seven transect samples; dissolved phase was lowest at the Multnomah Channel and RM 4 (31%) and highest at RM 1.8 (64%; the only sample with >50% dissolved phase).

3.3   Metals

Metals constituents discussed in this section were collected by peristaltic pump methods. The CULs for metals are based on either total recoverable (i.e., arsenic) or dissolved phase (i.e., chromium, copper, and zinc) concentrations. The data for both fractions for all metals are compared to the metal-specific CUL. The CUL is defined as "dissolved" or "total" in the figures and tables.

Arsenic

All sample concentrations of dissolved and total arsenic exceeded the CUL. Concentrations of total arsenic in the storm-flow event were consistent from RM 11.8 (0.53 micrograms per liter [µg/L]) through the Site (Figures 13 and 14, respectively), with total arsenic ranging from 0.44 µg/L at RM 7 to 0.61 µg/L (Multnomah Channel and RM 8.8). Total arsenic during the low-flow event was more variable, 0.61 µg/L at RM 11.8 and ranging within the Site from 0.64 µg/L (RM 8.8) to 0.97 µg/L (RM 1.8). Total arsenic during the high-flow event was highest at RM 16.2 (0.605 µg/L) compared to the highest Site concentration of 0.54 µg/L at RM 7. Dissolved arsenic followed a similar pattern during the low-flow and storm-flow events, with little variation

in the storm-flow event samples and increasing concentrations through the Site during the low-flow event to a maximum concentration observed at the RM 1.8. In the high-flow event, the concentration at RM 11.8 was higher than at RM 16.2, and concentrations throughout the Site were generally similar (0.28 to 0.34 µg/L).

Chromium

All sample concentrations of total and dissolved chromium were below the CUL. Total chromium was below detection limits during the low-flow event, with the exception of one sample at 5.2 µg/L at RM 8.8 (Figure 15). During the storm-flow event, total chromium was detected at the upstream Site boundary and throughout the Site, but concentrations were low (0.23 µg/L at RM 1.8 to 0.35 µg/L at the Multnomah Channel). In the high-flow event, concentrations of total chromium were lowest at RM 11.8 (0.65 µg/L) and ranged from 1.4 µg/L (RM 1.8 and the Multnomah Channel) to 1.9 µg/L (RM 7 and RM 8.8). Concentrations of dissolved chromium (Figure 16) were similar to total chromium in the storm-flow event. In the low-flow event, concentrations were higher at RM 8.8 (1.7 µg/L), RM 7 (10 µg/L), and RM 4 (1.5 µg/L). All other locations were below detection limits during the low-flow event. Dissolved chromium concentrations during the high-flow event were lower than total chromium, with concentrations ranging from 0.37 µg/L (Multnomah Channel and RM 7) to 0.75 µg/L (RM 11.8).

Copper

All sample concentrations of total copper were below the CUL. The maximum concentration of total copper was during the low-flow event (1.4 µg/L) at RM 16.2 (Figure 17). From the upstream Site boundary (RM 11.8) through the Site, concentrations of total copper ranged from 0.67 µg/L (RM 7) to 1.1 µg/L (RM 8.8, RM 4, and RM 1.8). Total copper was below detection limits at RM 16.2 and RM 4 during the storm-flow event. Remaining concentrations ranged from 0.62 µg/L (RM 1.8) to 0.79 µg/L (Multnomah Channel). Total copper concentrations were higher during the high-flow event than the other events, with concentrations ranging from 1.4 µg/L (RM 11.8) to 2.6 µg/L (RM 7). Dissolved copper concentrations were similar to total copper concentrations with the exception of RM 8.8 (3.4 µg/L) and RM 7 (2.4 µg/L) during the low-flow event (Figure 18). Dissolved copper concentrations during the high-flow event were similar to the other events, but lower than the low-flow concentrations at RM 16.2, RM 8.8, and RM 7.

Zinc

All sample concentrations of total and dissolved zinc were below the CUL. Like copper, the highest concentration of total zinc was detected at RM 16.2 during the low-flow event (3.1 µg/L), and detected concentrations from the upstream Site boundary (RM 11.8) through the Site were similar (Figure 19). During the storm-flow event, the highest concentrations of total zinc were at RM 8.8 (3.2 µg/L) and RM 7 (4 µg/L). Concentrations were generally higher during the high-flow event than the other events, with little range in concentration (3.2 µg/L at RM 11.8 to 5.7 µg/L at RM 7). Dissolved zinc was below detection limits in the low-flow and high-flow

events. In the storm-flow event, the concentration at RM 16.2 (2.8 µg/L) was the maximum concentration (Figure 20), with detected concentrations generally similar within the Site.

3.4   Other

Methylchlorophenoxypropionic acid, ethylbenzene, and tributyltin were not detected during the low-flow and storm-flow events, and all detection limits were below CULs. Bis(2-ethylhexyl)phthalate was detected twice, at 1.1 µg/L at RM 16.2 during the low-flow event and at 3.4 µg/L at RM 7 during the high-flow event. The detected concentration of bis(2-ethylhexyl)phthalate and the detection limits (0.94 to 1 µg/L) exceed the CUL (0.2 µg/L). Pentachlorophenol was detected only once (0.022 µg/L at RM 8.8 during the storm-flow event). The detected concentration of pentachlorophenol and the detection limits achieved by Analytical Resources Inc. (0.025 µg/L) are below the CUL (0.03 µg/L). These data and comparisons to CULs are presented in Appendix D.9 to this PDI Evaluation Report.

4.   COMPARISON OF PDI SURFACE WATER DATA TO RI SURFACE WATER DATA

This section compares the three rounds of PDI surface water sampling results to the surface water sampling conducted for the RI. For each of the PDI events, a comparable event from the RI was selected. The 2006 surface water sampling (Round 3A) was chosen as the representative RI dataset for low-flow and storm-flow conditions, and the 2007 event from the RI was selected as the representative dataset for high-flow conditions. The framework of the PDI sampling was modeled more closely on the Round 3A RI sampling than on other RI events, based on the number and locations of transects sampled, including the addition of the Multnomah Channel transect.

The locations of transects sampled during the RI and PDI events evaluated in this appendix are provided in Figure 21. Tables 4 through 6 provide RI/PDI summary comparisons of the low-flow, storm-flow, and high-flow events, respectively, evaluated in this appendix. Figures 22, 23, and 24 provide sampling duration (days sampled) and the average daily flow (i.e., discharge, in cfs, measured as daily average at the USGS gage 14211720) for the low-flow, storm-flow, and high-flow events, respectively. Comparisons for each event type are provided in the following subsections. While the RI and PDI events targeted similar river flow conditions, differences in river flows, locations, and methods for compositing make direct comparison of the PDI and RI datasets subject to some uncertainty. Differences and similarities are discussed below.

4.1   Low-Flow Surface Water Sampling Comparison: RI and PDI

The differences in the sampling methods between the 2006 RI and 2018 PDI low-flow surface water sampling events are described below (Table 4):

- In 2006, in order to provide greater spatial resolution, high-volume samples were composited horizontally as near bottom (NB) and near surface (NS) samples or vertically as east bank (E), west bank (W), and mid-channel (M) samples (i.e., two or three samples per transect). The 2018 PDI high-volume samples were composited horizontally and vertically (i.e., one composite sample per transect). To provide a closer comparison between RI and PDI data, the individual samples collected during the RI from a transect were averaged to create one data point per transect.

- There were six transects in 2006 and seven in 2018; the transect at RM 4 (W005 in RI; Transect 3 in PDI) was the only transect sampled at the exact same RM for both 2018 and 2006 (Table 4). Other transects were located within close proximity between the RI and PDI, with the exception of PDI transects 4 and 5 at RM 7 and RM 8.8, respectively.

- Sampling for both 2006 and 2018 events occurred in late summer. The flow in the river was comparable between the two events. Average daily flow during the RI ranged from 5,430 to 8,990 cfs; during the PDI, the range was 5,041 to 8,697 cfs (Figure 22).

- The conditions in the river with respect to turbidity were generally similar, with turbidity during the RI ranging from zero (note: the value was recorded as -2.9 in the FSR) to 5.5 NTU and turbidity in the PDI being higher with a range from 2.8 to 23.9 NTU.

- TSS concentrations in the RI dataset, ranging from <1 mg/L to 16 mg/L, were generally comparable to the PDI dataset, which ranged from 2.6 mg/L to 7.8 mg/L. The RI TSS concentrations were higher than PDI concentrations, particularly at RM 6.3 and RM 4.

- As summarized in Table 4, DOC and TOC were not detected during the 2006 RI low-flow sampling, but ranged from 1.8 to 5.0 mg/L (DOC) and 1.4 to 4.5 mg/L (TOC) during the PDI low-flow sampling. Forest fires were severe in the Pacific Northwest in both 2006 (National Interagency Fire Center 2006) and 2018 (Bureau of Land Management and U.S. Department of Agriculture Forest Service 2018). In 2018 however, fires were near Portland, impacting air quality, which was not noted in the 2006 sampling. The air quality index (AQI) in 2006 during the low-flow sampling in August 2006 was approximately 35 to 40 (98th percentile of August 2006) (Oregon Department of Environmental Quality 2006). In 2006, Portland experienced 325 days with an AQI "good" and only one day considered "Unhealthy for Sensitive Groups" when the AQI is 101 to 150. There were no days with an AQI greater than 150. In 2018, during the sampling period for the low-flow event, the AQI was "Unhealthy" (151 to 200) from August 20 to 22, then "Moderate to Good" on August 23 and 24, 2018.[3] The AQI is calculated from air quality data including the $PM_{2.5}$ concentration, which is the concentration of particulate matter smaller than 2.5 micrometers. $PM_{2.5}$ is linked to forest fire smoke. This may have impacted concentrations of carbon fractions in the river in 2018 and may have added ambient (i.e., air-borne) contamination to the system.

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[3] https://gispub.epa.gov/airnow/

- During high-volume sampling, approximately 500 L of water was sampled per station in 2006, and 400 L was sampled per transect in 2018.

Qualification of Data

Overall, data quality was comparable between events with some differences by analyte groups in the frequency of detection and frequency of data qualification (i.e., assignment of J-flags) that was assigned during validation. In general, frequency of detection was higher for PCBs, DDx, and PAHs in the 2018 data relative to the 2006 data. Frequency of qualification was also higher for these analyte groups in 2018 than in 2006, which may be due to the increased detections close to analytical detection limits. A summary of the detection limits for the low-flow RI and PDI sampling events is provided in Table 7. In general, the particulate fraction detection limits were within the same order of magnitude for dioxin and furans and PCBs. Detection limits were an order of magnitude lower in particulate DDx compounds in the PDI data. PAH detection limits were similar in the dissolved phase, but one to three orders of magnitude lower in the PDI data for dioxins and PCBs. Frequency of detection for dioxins and furans was lower in 2018 than in 2006. Frequency of qualification of the analytical results and frequency of detection (individual congeners and isomers) for four analyte groups from the 2018 PDI low-flow event are provided in Table 7.

Physical Parameters

- During the 2018 sampling, weather conditions were dry and there were multiple forest fires in the Pacific Northwest. Neutrally buoyant particles, assumed to be dead algae blooms or potentially soot, were present in high density throughout the river. These particles were abundant enough to cause rapid clogging of the filtration system of the high-volume sampler, resulting in multiple flat filter changes. Details of this are presented in Appendix B.5 (Surface Water FSR).

- TSS concentrations were generally lower during the 2018 sampling than during 2006 (Figure 25) but were comparable at RM 16/16.2 (in the D/U Reach).

Concentrations of Focused COCs in Whole Water by RM

- PCBs (Figure 26)
  - Concentrations of total PCBs in the samples from RM 16.2 (in the D/U Reach) from 2018 were comparable to RM 16.0 from the RI in 2006.
  - Concentrations of total PCBs in the middle of the Site (i.e., RM 4 through 7), and in Multnomah Channel, were lower in 2018 than in 2006. Concentrations of total PCBs near RMs 4 and 7 were 38% to 50% lower, respectively, in 2018 as compared to 2006. Concentrations in the Multnomah Channel during the PDI low-flow were approximately 50% of the RI low-flow samples.

- o Concentrations of total PCBs at the downstream Site boundary (PDI RM 1.8 and RI RM 2) were comparable between 2018 and 2006.

- DDx (Figure 27)

  - o Concentrations of DDx in the samples from the two upstream transects in 2018 were comparable to RM 11 and RM 16 from 2006.

  - o In both events, concentrations increased at RM 7 compared to upstream concentrations. In 2018, the concentrations decreased at RM 4 relative to RM 7, whereas they continued to increase relative to concentrations at RM 7 in 2006.

  - o Concentrations of DDx were lower in 2018 than in 2006 from RM 4 to RM 1.8.

- TCDD-TEQ (Figure 28)

  - o Concentrations of TCDD-TEQ in surface water followed a similar spatial pattern through the Site during the 2006 and 2018 low-flow events. TCDD-TEQ concentrations were similar coming into the Site in both 2006 (RM 11 and RM 16) and 2018 (RM 11.8 and RM 16.2), then increased at RM 7, and decreased again near the downstream end of the Site (RM 1.9).

  - o The highest concentration during 2006 was at RM 4 (0.142 pg/L), with the lowest concentration (0.0283 pg/L) at RM 2.

  - o Concentrations of TCDD-TEQ in 2018 were highest at RM 7 (0.0952 pg/L) but were lower than the highest concentrations observed in 2006. Concentrations of TCDD TEQ were similar at the upstream boundary at RM 16.2 (0.022 pg/L) in 2018 compared to 2006 (at RM 16).

  - o Overall, concentrations of TCDD-TEQ were lower between the Multnomah Channel and RM 7 in 2018 than in 2006.

- BaP-TEQ (Figure 29)

  - o Concentrations of BaP-TEQ in the upstream transects from 2018 (0.179 and 0.223 ng/L at RM 16.2 and RM 11.8, respectively) are lower than those detected in 2006 (0.265 ng/L at RM 16).

  - o BaP-TEQ concentrations between RM 4 and RM 9 were much lower in 2018 (0.304 to 1.21 ng/L) than in 2006 (2.45 to 2.85 ng/L).

  - o At the downstream boundary of the Site, concentrations in 2018 (0.625 ng/L at RM 1.8) were higher than in 2006 (0.263 ng/L at RM 2).

  - o Concentrations of BaP-TEQ were lower in 2018 than in 2006 from RM 16.2 to the Multnomah Channel.

<u>Comparison of Fractions (Exhibit F)</u>

- In most samples, the dissolved fraction comprised a higher percent of the whole water concentration for total PCBs than the particulate fraction (Figure F-1). The PCB concentration in the whole water samples from 2006 consists of 45% to 97% dissolved fraction and 59% to 76% in 2018. This pattern of observing a higher percentage of PCBs in the dissolved fraction is consistent between 2006 and 2018 low-flow data.

- Dissolved and particulate fractions are generally different for DDx, with the contributions from particulate fraction concentrations similar to those from the dissolved fraction in 2018 (Figure F-2) than in 2006. In 2006, all transects except RM 6.3 indicated a higher contribution of the dissolved phase to total concentrations.

- For TCDD-TEQ and BaP-TEQ, the particulate fraction dominates the contributions to respective whole water concentrations relative to the dissolved phase in both 2006 and 2018 datasets (Figures F-3 and F-4).

<u>Concentrations of COCs as a Function of TSS</u>

- Concentrations of total PCBs, DDx, TCDD-TEQ, and BaP-TEQ in whole water have similar positive correlations to TSS in 2006 (Figures F-5 through F-8). In 2018, the relationship of total PCBs, DDx, TCDD-TEQ, and BaP-TEQ in whole water to TSS remains positive but is not as strong.

<u>Concentrations of TSS as a Function of Discharge</u>

- TSS is presented as a function of river discharge (flow) in Figure F-9. Flows (average flow used if sample collected over more than 1 day) were lower in 2018 (5,000 to 6,800 cfs) than during the 2006 low-flow RI sampling (7,600 to 8,270 cfs).

- TSS was mostly in the same range for both sampling events but was more variable with lower maximum concentrations during the 2018 sampling (2.6 to 7.8 mg/L) than during the RI sampling (3 to 12 mg/L).

4.2   Storm-Flow Event Surface Water Sampling Comparison: RI and PDI

The differences in the methods between the 2006 RI and 2018 PDI storm-flow surface water sampling events are described below (Table 5):

- As with the 2006 low-flow sampling, in order to provide greater spatial resolution in the RI, high-volume samples were composited horizontally as NB and NS samples or vertically as E, W, and M samples (i.e., two or three samples per transect). The 2018 PDI high-volume samples were composited horizontally and vertically (i.e., one composite sample per transect).

- There were 18 sampling locations (point and transect) in 2006 and seven in 2018. Only six of the sampling locations from the 2006 storm-flow event were transects (W025 at RM 2, W027 in the Multnomah Channel, W005 at RM 4, W011 at RM 6.3, W023 at RM 11, and W024 at RM 16); the remaining 12 locations were sampled as NB/NS only and were not sampled across a transect. These samples are identified in Figure 21.

- For most PDI transects, a storm-flow event sample from the RI was sampled within 0.2 RM.

- Not all samples collected in 2006 were analyzed for the full suite of high-volume analytes. While PCBs were analyzed in all samples, dioxins and furans and PAHs were analyzed in 9 samples, and pesticides were analyzed in 11 samples (Table 5).

- Sampling for both events occurred in November. The flow in the river was comparable between the two events. Average daily flow during the PDI was 16,780 to 27,407 cfs; during the RI, average daily flow ranged from 16,200 to 26,200 cfs (Figure 23).

- The total daily rainfall during the 2006 storm-flow event (3.09 inches) was substantially higher than in 2018 (1.57 inches).

- The conditions in the river with respect to turbidity were generally similar, with turbidity during the PDI ranging from 0.94 to 3.07 NTU and turbidity in the RI generally higher, with a range from 1.22 to 6.51 NTU.

- TSS was also higher in the RI dataset, ranging from <1 to 7 mg/L, compared to <2.0 to 3.6 mg/L in the PDI.

- TOC ranged from 1.7 to 5 mg/L in the RI samples and was lower in the PDI samples, ranging from 1.4 to 2.3 mg/L. DOC ranged from 1.4 to 1.7 mg/L in the RI and was higher in the PDI samples, ranging from 1.7 to 2.3 mg/L.

- During high-volume sampling in 2006 storm-flow sampling event, 31 to 121 L per sub-sample were collected (66 to 328 L per transect or sample), and 150 to 225 L were sampled per transect in 2018.

Qualification of Data

Overall, data quality was comparable between events with some differences by analyte groups in the frequency of detection and frequency of data qualification that was assigned during validation. In general, frequency of detection was higher for dioxins and furans, PCBs, DDx, and PAHs in 2018 relative to 2006. A summary of the detection limits for the storm-flow RI and PDI sampling events is provided in Table 8. The detection limits in the particulate phase in the PDI were lower than RI by up to three orders of magnitude for dioxins and furans and two orders of magnitude lower for PCBs. DDx detection limits were similar between events. In the dissolved phase, PDI detection limits were lower by an order of magnitude for dioxins and furans and DDX, and by two orders of magnitude for PCBs and PAHs.

Frequency of qualification (assignment of J-flags) for these analyte groups was also higher in the 2018 data than in 2006, reflecting the increased detections at concentrations close to the analytical detection limits. Frequency of qualification of the analytical results and frequency of detection (individual congeners and isomers) for four analyte groups from the 2018 PDI low-flow event are provided in Table 8.

Physical Parameters

- TSS were generally lower during the 2018 sampling than during 2006 (Figure 30) but were comparable at the Multnomah Channel.

Concentrations of COCs in Whole Water by RM

- PCBs (Figure 31)

  o All concentrations of total PCBs exceeded the CUL.

  o Concentrations of total PCBs in the samples from RM 16.2 in 2018 (in the D/U Reach) were comparable to 2006 (RM 16.0).

  o Concentrations of total PCBs in the middle of the Site (i.e., RM 4 through 8.8) were similar in 2018 and 2006, with the exception of one high total PCB sample in a point sample at RM 5.5 in 2006.

  o Concentrations of total PCBs in the Multnomah Channel in 2006 (320 pg/L) were higher than in 2018 (188 pg/L).

  o Concentrations of total PCBs at the downstream Site boundary (RM 1.8; 190 pg/L) were much lower in 2018 than at RM 2 (643 pg/L) in 2006.

  o Overall, concentrations of total PCBs were lower in 2018 than in 2006.

- DDx (Figure 32)

  o None of the samples exceeded the ROD CUL.

  o Concentrations of DDx in the samples from RM 8.8 to the upstream samples at RM 16.2 from 2018 were comparable to samples from RM 8.5 to RM 16 in 2006.

  o In both events, concentrations increased at RM 7 compared to upstream concentrations, then decreased, with the exception of the concentration in the Multnomah Channel from the PDI event, which was higher than RM 7.

  o Concentrations at the downstream boundary of the Site were similar in 2006 and 2018.

  o Overall, concentrations of DDx were lower in 2018 than in 2006.

- TCDD-TEQ (Figure 33)

  o All concentrations exceeded the CUL. As with the PDI data, the detection limits for the individual dioxin and furan congeners in the RI data exceeded the CUL by at least an order of magnitude.

  o Concentrations of TCDD-TEQ in surface water were generally lower in 2018 than in 2006, including the locations upstream of the Site (RM 11.8 through RM 16.2).

  o The highest concentration during 2006 was at RM 7 (0.175 pg/L), with much lower concentration (0.067 pg/L) at RM 2.

  o Concentrations of TCDD-TEQ in 2018 were highest in the Multnomah Channel (0.0933 pg/L), with a lower concentration (0.0668 pg/L) at the downstream Site boundary (RM 1.8).

- BaP-TEQ (Figure 34)

  o All concentrations exceeded the CUL.

  o Concentrations of BaP-TEQ in 2018 were lower than in 2006 at every location, including RM 16.2 (the D/U Reach transect) and RM 11.8 (upstream Site boundary).

  o BaP-TEQ concentrations from in 2018 were highest in the Multnomah Channel (0.827 ng/L); the highest concentration from 2006 was at RM 7 (2.7 ng/L).

  o At the downstream boundary of the Site, concentrations in 2006 (1.93 ng/L at RM 2) were much higher than in 2018 (0.476 ng/L at RM 1.8).

Comparison of Fractions (Exhibit G)

- For PCBs (Figure G-1), the dissolved fraction comprises a higher percent (average of 51% in 2018 and 58% in 2006) of the whole water concentration than the particulate fraction. The PCB concentration in the whole water samples from 2018 consists of 38 to 66% dissolved fraction. This pattern of observing a higher percentage of PCBs in the dissolved fraction is generally consistent with 2006 (37 to 88% dissolved); however, locations with a higher contribution of dissolved fraction differed between the two events. In 2006, lower dissolved fraction was observed in 3 of the 18 locations (RM 6.9, RM 8.5, and RM 11). In 2018, a lower dissolved fraction was observed in Multnomah Channel, RM 7, and RM 11.8.

- For DDx (Figure G-2), the particulate fraction comprises a higher contribution to total concentrations in 2018 than in 2006. In 2006, approximately half the samples indicated a higher contribution of the dissolved phase to total concentrations.

- For TCDD-TEQ (Figure G-3), the particulate fraction dominates the contributions to the whole water concentrations in 2006 and 2018.

- For BaP-TEQ (Figure G-4), the particulate fraction dominates the contributions to whole water concentrations in the 2018 dataset, while there is a mix in 2006, with four samples having higher detected concentrations of dissolved phase than particulate phase.

Concentrations of COCs as a Function of TSS

- The ability to correlate COC concentrations to TSS is limited due to the low frequency of detection in TSS concentrations during the 2018 storm-flow event.

- Concentrations of total PCBs (Figure G-5) shows a negative correlation to TSS in the PDI data and the RI point data, but a positive correlation to the RI transect data.

- DDx (Figure G-6) has a positive correlation to TSS in the PDI data, RI transect data, and point data.

- In 2006, TCDD-TEQ and TSS demonstrate a negative correlation (Figure G-7); in 2018, the correlation is positive.

- BaP-TEQ (Figure G-8) in whole water is positively correlation to TSS in 2006 and 2018.

Concentrations of TSS as a Function of Discharge

- TSS from the storm-flow events is presented as a function of river discharge (flow) in Figure G-9. Flows (average flow used if sample collected over more than 1 day) were similar between the two events.

- TSS was higher in 2006 (3 to 6 mg/L) than in 2018 (<2 to 3.6 mg/L), but the detected concentrations of TSS during 2018 were at the higher flows (>25,000 cfs). Several of the higher concentrations of TSS during 2006 sampling occurred at lower (16,200 cfs) to mid-level (20,300 cfs) flows.

4.3   High-Flow Event Surface Water Sampling Comparison: RI and PDI

The differences in the methods between the 2006 RI and 2019 PDI high-flow surface water sampling events (Table 6) are described below:

- Consistent with other events, in order to provide greater spatial resolution in the RI, high-volume samples were composited horizontally as NB and NS samples or vertically as E, W, and M samples (i.e., two or three samples per transect). The PDI high-volume samples were composited horizontally and vertically (i.e., one composite sample per transect).

- The RI high-flow sampling was similar to the RI storm-flow sampling. There were 18 sampling locations (point and transect) in 2007 and seven in 2019. Only six of the sampling locations from the 2007 high-flow event were transects (W025 at RM 2, W027 in the Multnomah Channel, W005 at RM 4, W011 at RM 6.3, W023 at RM 11, and W024 at RM 16); the remaining 12 locations were sampled as NB/NS only and were not sampled across a transect. These samples are identified in Figure 21.

- For most PDI transects, a high-flow event sample from the RI was within 0.2 RM.

- Not all samples collected in 2006 were analyzed for the full suite of high-volume analytes. While PCBs were analyzed in all samples, dioxins and furans and PAHs were analyzed in 9 samples, and pesticides were analyzed in 11 samples (Table 6).

- Sampling for both events occurred in two phases. Both events started in mid-January and were suspended when flows dropped below the 50,000 cfs threshold. In the RI, two locations (W023M and W025M) were sampled in January and resampled during the second mobilization when the E and W samples from these transects were sampled. The January data were not included in this evaluation.

- Sampling for both events was continued in mid-February. The flow in the river was generally higher during the RI than the PDI events. Average daily flow during the RI ranged from 48,500 to 72,600 cfs; during the PDI, the range was 45,706 to 55,781 cfs (Figure 24).

- The conditions in the river with respect to turbidity were different, with turbidity during the RI ranging from 0 to 28.1 NTU and turbidity in the PDI generally lower with a range from 0.9 to 16.6 NTU.

- TSS was much higher in the RI dataset, ranging from 10 to 38.5 mg/L, compared to 2.4 to 9.8 mg/L in the PDI.

- TOC ranged from 1.4 to 2.3 mg/L in the RI samples and was higher in the PDI samples, ranging from 1.83 to 4.31 mg/L. DOC ranged from 1.3 to 2.2 mg/L in the RI and was higher in the PDI samples, ranging from 2.07 to 3.75 mg/L.

- During high-volume sampling in 2007 high-flow sampling event, 168 to 515 L per sub-sample were collected (338 to 1,459 L per transect or sample), and 400 to 422 L were sampled per transect in 2019.

Qualification of Data

Overall, data quality was comparable between events with some differences by analyte groups in the frequency of detection and frequency of data qualification that was assigned during validation. In general, frequency of detection was higher for dioxins and furans, PCBs, DDx, and PAHs in 2019 relative to 2007. Detection limits for the PDI particulate phase data were close to the RI detection limits for dioxins and furans and PCBs; PAHs were an order of magnitude lower in the PDI data. The detection limits for the PDI dissolved phase data were two orders of magnitude lower for dioxins and furans, PCBs, and PAHs.

Frequency of qualification (assignment of J-flags) for these analyte groups was also higher in the 2019 data than in 2007, reflecting the increased detections at concentrations close to the analytical detection limits. Frequency of qualification of the analytical results and frequency of detection (individual congeners and isomers) for four analyte groups from the 2018 PDI low-flow event are provided in Table 9.

<u>Physical Parameters</u>

- TSS were lower during the 2019 sampling than during 2007 (Figure 35). This may be due to the higher flows observed during the RI sampling.

<u>Concentrations of COCs in Whole Water by RM</u>

- PCBs (Figure 36)

  o All concentrations of total PCBs exceeded the CUL.

  o Concentrations of total PCBs in the samples from RM 16.2 in 2019 (in the D/U Reach) were comparable to 2007 (RM 16.0).

  o Concentrations of total PCBs in the middle of the Site (i.e., RM 4 through 8.8) were generally higher in 2007 than 2019. The exception is RM 7 where concentrations were similar (183 pg/L in 2019 and 188 pg/L in 2007).

  o Concentrations of total PCBs in the Multnomah Channel in 2007 (263 pg/L) were higher than in 2019 (118 pg/L).

  o Concentrations of total PCBs at the downstream Site boundary in 2019 (RM 1.8; 178 pg/L) were similar to but slightly higher than at RM 2 in 2007 (142 pg/L).

  o Overall, concentrations of total PCBs were lower in 2019 than in 2007.

- DDx (Figure 37)

  o None of the samples exceeded the ROD CUL.

  o Concentrations of DDx in the samples from 2007 were comparable to samples from 2019.

  o In 2007, concentrations increased at RM 7 compared to upstream concentrations, then decreased. In 2019, the concentrations on the Site were similar to the upstream sample at RM 16.2.

- TCDD-TEQ (Figure 38)

  o All concentrations exceeded the CUL. As with the PDI data, the detection limits for the individual dioxin/furan congeners in the RI data exceeded the CUL by at least an order of magnitude.

  o Concentrations of TCDD-TEQ in surface water were generally similar in 2007 and 2019, although the location upstream of the Site (RM 16.2) was higher in 2019 (0.0657 pg/L) compared to RM 16 in 2007 (0.0264 pg/L).

  o The highest concentration during 2007 was at RM 8.5 (0.162 pg/L), with much lower concentration (0.034 pg/L) at RM 2.

  o Concentrations of TCDD-TEQ in 2019 were highest at RM 7 (0.12 pg/L), with a lower concentration (0.0355 pg/L) at the downstream Site boundary (RM 1.8).

- BaP-TEQ (Figure 39)

  o All concentrations exceeded the CUL with the exception of RM 16 in 2007 (0.106 ng/L).

  o Concentrations of BaP-TEQ in 2019 were lower than in 2007 at every location with the exception of the upstream samples where the concentration in 2007 at RM 16 (0.106 ng/L) was lower than at RM 16.2 in 2019 (0.253 ng/L).

  o BaP-TEQ concentrations from the RI in 2007 were highest at RM 8.5 (6.86 ng/L), which appears to be an outlier concentration. The highest concentration in 2019 PDI high-flow was in the Multnomah Channel (0.388 ng/L).

  o At the downstream boundary of the Site, concentrations in 2007 (0.499 ng/L at RM 2) were higher than in 2019 (0.280 ng/L at RM 1.8).

Comparison of Fractions (Exhibit H)

- For PCBs (Figure H-1), the dissolved fraction comprises a lower percent (average of 43% in 2019 and 46% in 2007) of the whole water concentration than the particulate fraction. The PCB concentration in the whole water samples from 2019 consists of 31 to 64% dissolved fraction. This pattern of observing a higher percentage of PCBs in the dissolved fraction is generally consistent with 2007 (28 to 71% dissolved); however, locations with a higher contribution of dissolved fraction differed between the two events. In 2007, higher dissolved fraction was observed in 6 of the 18 locations (RM 2, RM 2.2, RM 3.6, RM 5.5, RM 7.4, and RM 16), with the highest dissolved fraction (71%) observed at RM 16. In 2019, a higher dissolved fraction was observed only at RM 1.8.

- For DDx (Figure H-2), the particulate fraction comprises a higher contribution to total concentrations in 2019 than in 2007. In 2007, samples were 53% (RM 16) to 70% (RM 11) particulate. In 2019, samples were 78% (RM 11.8) to 88% (RM 8.8) particulate.

- For TCDD-TEQ (Figure H-3), the particulate fraction dominates the contributions to the whole water concentrations in 2007 and 2019.

- For BaP-TEQ (Figure H-4), the particulate fraction dominates the contributions to whole water concentrations in the 2019 dataset (95% to 99% particulate). In 2007, the particulate fraction was high (59% to 94%), but slightly lower than in 2019.

Concentrations of COCs as a Function of TSS

- Concentrations of total PCBs (Figure H-5), DDx (Figure H-6), TCDD-TEQ (Figure H-7), and BaP-TEQ (Figure H-8) in whole water show positive correlations to TSS in the PDI data.

<u>Concentrations of TSS as a Function of Discharge</u>

- TSS from the high-flow events is presented as a function of river discharge (flow) in Figure H-9. Flows (average flow used if sample collected over more than one day) were much higher during the RI sampling in 2007 than the PDI sampling in 2019.

- TSS was higher in 2007 (10 to 38.5 mg/L) than in 2019 (2.4 to 9.8 mg/L), and TSS increases with flow.

5. SUMMARY

This section provides a general overview of the PDI data, comparisons between the three PDI events (Section 5.1), and a comparison to RI data (Section 5.2) from sampling events with similar conditions (i.e., low-flow, storm-flow, and high-flow conditions). The PDI and RI were event-based sampling, so some variation in results is expected. Comparisons of the PDI transect data among events and transects are more meaningful than the comparisons to RI data.

5.1 General Observations of 2018/2019 Data – Implications for the CSM

Concentrations of COCs and physical analytes in surface water followed a similar pattern between the three PDI sampling events, with some exceptions.

<u>2018/2019 Results and Comparison to ROD CULs</u>

- COCs exceeding CULs in all upstream and Site transect samples included total PCBs, TCDD-TEQ, BaP-TEQ, and arsenic.

- None of the DDx and total chlordane samples exceeded their respective CULs. Concentrations of most pesticides were also lower than their CULs. With the exception of the high-flow event, samples collected from the upstream transects (i.e., RM 11.8 and RM 16.2) had lower concentrations than samples collected from the Site. Upstream samples had notably higher levels of pesticides, including DDx and total chlordanes, during the high-flow event than the other events.

- For other COCs:

  o Aldrin exceeded CULs in all low-flow and high-flow samples from within the Site, but in only two of seven storm-flow samples (at RM 8.8 and in the Multnomah Channel).

  o Hexachlorobenzene, which was dominated by the dissolved fraction in all samples, exceeded the CUL in four of the storm-flow samples from within the Site and at RM 16.2, but not the low-flow or high-flow samples.

  o Concentrations of total and dissolved copper, chromium, and zinc were below their respective CULs with the exception of one low-flow sample for dissolved copper.

Concentration Comparison among PDI Sampling Events

- TSS, TOC, DOC, total chlordanes, and DDx were generally the higher during the high-flow event. The lower TSS and carbon fractions (DOC and TOC) during the storm-flow event may be due to increased volumes of water entering the system but with the bedded sediments not mobilized, as was seen during the sustained high-flow event.

- During the low-flow event, TSS and COC concentrations were highest at either RM 4, before the river discharge is split into the main stem and Multnomah Channel, or RM 7, depending on the COC. During the storm-flow event, concentrations of BaP-TEQ, TCDD-TEQ, aldrin, total chlordanes, and DDx at the Multnomah Channel transect were elevated compared to the downstream-most Site transect (RM 1.8). During the high-flow event, the highest TSS and COC concentrations occurred in different transects: TSS, TCDD-TEQ, and PCBs at RM 7, BaP-TEQ and DDx in the Multnomah Channel, total chlorobenzenes and hexachlorobenzene at RM 4. At high flow, arsenic concentrations were similar across the Site.

- Concentrations of all analytes were lower in the upstream transects than in the Site, with noted exceptions:
  - During the storm-flow event, concentrations of aldrin, total chlordanes, and TCDD-TEQ were higher at the upstream transects than in the middle and/or lower transects of the Site.
  - In the high-flow event, TCDD-TEQ was lower at RM 1.8 than in the upstream transects.
  - DOC and TOC were higher in the upstream transects than in Site transects during low-flow.

- Other COCs below the ROD CULs are not discussed.

5.2   General Observations – Comparison to RI Data

Based on the evaluation of the 2018/2019 PDI surface water data and comparison to the 2006/2007 RI surface water data, the following are important observations:

- 2018/2019 PDI surface water concentrations are lower than RI samples for all COCs evaluated in this appendix. For the focused COCs, the greatest reductions from the PDI to the RI were for DDx and BaP-TEQ. In general, these reductions were more pronounced during the low-flow event.
  - Concentrations of the focused COCs (total PCBs, B(a)P-TEQ, DDx, and TCDD-TEQ) were lower in 2018 for the low-flow and the storm-flow events. TCDD-TEQ and DDx concentrations were generally similar.

- During high-flow sampling, the 2019 PDI concentrations were lower than RI samples for total PCBs and BaP-TEQ, but not for TCDD-TEQ or DDx, for which the results are similar.

- Surface water concentrations for PCBs and BaP-TEQ were generally higher during the low-flow events compared to the storm-flow and high-flow events, consistent with the CSM. On the other hand, DDx was generally highest during the high-flow event. A consistent pattern was not observed for TCDD-TEQ.

- Total PCBs, TCDD-TEQ, BaP-TEQ, and arsenic exceeded CULs in all PDI samples, including upstream; however, the concentrations of these COCs were lower in the D/U Reach than within the Site. This indicates that there is an ongoing upstream source, at least relative to the low concentrations at which the CULs were set.

- In general, the upstream concentrations from the PDI samples were similar to concentrations observed during the RI, with the exceptions of TCDD-TEQ and BaP-TEQ during the storm-flow event, which were lower in 2018 than in 2006; the opposite was true during the high-flow event (2019 concentrations were higher than 2006 concentrations).

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TABLES

Table 1. Summary Statistics for 2018 PDI Low-Flow Sampling Event

Chemical	CAS Number	Record of Decision Cleanup Level	Units	Frequency of Detection (a)	FOD % (a)	Minimum Detected Concentration (b)	Qual	Maximum Detected Concentration (b)	Qual	Mean Detected Concentration (c)	Median Detected Concentration (c)	Location of Maximum Concentration	Minimum Reporting Limit (d)	Maximum Reporting Limit (d)
Dioxins and Furans														
TCDD-TEQ (PDI) (e)	T_DF_TEQ (PDI)	0.0005	pg/L	7 : 7	100%	0.0228		0.0977		0.0621	0.0651	T04	--	--
Polychlorinated Biphenyls (PCBs)														
Total PCBs (PDI) (e)	T_PCBCg (PDI)	6.4	pg/L	7 : 7	100%	203		591		385	381	T03	--	--
Pesticides														
DDD	T_DDD (PDI)	0.031	ng/L	7 : 7	100%	0.0207		0.248		0.095	0.0779	T04	--	--
DDE	T_DDE (PDI)	0.018	ng/L	7 : 7	100%	0.0311		0.103		0.065	0.0651	T04	--	--
DDT	T_DDT (PDI)	0.022	ng/L	7 : 7	100%	0.00671		0.0652		0.022	0.0138	T04	--	--
DDx (PDI)	T_DDx (PDI)	10	ng/L	7 : 7	100%	0.0585		0.417		0.182	0.169	T04	--	--
Total Chlordanes (PDI) (e)	T_Clrdn (PDI)	0.081	ng/L	7 : 7	100%	0.0163		0.0292		0.0223	0.0214	T04	--	--
Aldrin	309-00-2	0.00077	ng/L	7 : 7	100%	0.000663	J	0.00287	J	0.00198	0.00222	T03	--	--
Semivolatile Organics														
Hexachlorobenzene	118-74-1	0.029	ng/L	7 : 7	100%	0.0122	J	0.0222	J	0.0171	0.0191	T04	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)														
BaP-TEQ (PDI) (e)	T_BaP-TEQ (PDI)	0.12	ng/L	7 : 7	100%	0.179		1.21		0.568	0.562	T03	--	--
Inorganics (Dissolved) (f)														
Arsenic	7440-38-2	0.018 (g)	µg/L	7 : 7	100%	0.58	J	0.96	J	0.7	0.64	T01	--	--
Chromium	7440-47-3	100	µg/L	3 : 7	43%	1.5	J	6	J	3.1	1.7	T04	0.4	0.4
Copper	7440-50-8	2.74	µg/L	7 : 7	100%	0.73	J	3.4		1.4	1	T05	--	--
Zinc	7440-66-6	36.5	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	7	7
Inorganics (Total) (f)														
Arsenic	7440-38-2	0.018 (g)	µg/L	7 : 7	100%	0.6	J	0.97	J	0.75	0.8	T01	--	--
Chromium	7440-47-3	100	µg/L	1 : 7	14%	5.2	J	5.2	J	5.2	5.2	T05	0.4	0.4
Copper	7440-50-8	2.74	µg/L	7 : 7	100%	0.72	J	1.4	J	1	1.1	T07	--	--
Tri-n-butyltin	36643-28-4	0.063 (g)	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	0.05	0.05
Zinc	7440-66-6	36.5	µg/L	6 : 7	86%	2.1	J	3.1	J	2.5	2.3	T07	7	7
Semivolatile Organics														
Bis(2-ethylhexyl)phthalate	117-81-7	0.2	µg/L	1 : 7	14%	1.1	J	1.1	J	1.1	1.1	T07	0.94	1
MCPP	93-65-2	16	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	1.1	1.1
Pentachlorophenol (ARI)	87-86-5	0.03	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	0.025	0.025
Pentachlorophenol (Kelso)	87-86-5	0.03	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	0.94	1
Ethylbenzene	100-41-4	7.3	µg/L	0 : 21	0%	ND		ND		ND	ND	ND	3	3

Table 1. Summary Statistics for 2018 PDI Low-Flow Sampling Event

Chemical	CAS Number	Record of Decision Cleanup Level	Units	Frequency of Detection (a)		FOD % (a)	Summary Statistics							
							Minimum Detected Concentration (b)	Qual	Maximum Detected Concentration (b)	Qual	Mean Detected Concentration (c)	Median Detected Concentration (c)	Location of Maximum Concentration	Minimum Reporting Limit (d)	Maximum Reporting Limit (d)
Physical Parameters															
Dissolved Organic Carbon	DOC	NA	mg/L	7 : 7		100%	1.8	J	5	J	2.6	2.15	T07	--	--
Total Dissolved Solids	TDS	NA	mg/L	7 : 7		100%	30		71		49	44	T01	--	--
Total Organic Carbon	TOC	NA	mg/L	7 : 7		100%	1.7	J	4.5	J	2.5	2.2	T07	--	--
Total Suspended Solids	TSS	NA	mg/L	7 : 7		100%	2.6		7.8		4.5	4.2	T03	--	--

Notes:
a. FOD is defined as the number of detects out of the total number of samples.
b. Minimum/maximum detected concentration; associated data flags shown in Qual column.
   J = The chemical was positively identified; however, the associated numerical value is an estimated concentration.
   JN = The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
   +/- = Indicates the result may be biased high/low.
c. Arithmetic mean and median calculated using detected results only.
d. Lab Reporting Limits are shown where the frequency of detection is less than 100%.
e. Totals and TEQs were calculated using EPA Region 10's 12/12/2017 data summation rules for the PDI, with clarifications in AECOM's
   8/31/2018 memorandum (see Appendix C.3).
f. CULs for metals are based on the dissolved phase unless otherwise indicated. Dissolved phase CULs conservatively compared to total recoverable and dissolved phase.
g. CUL based on total recoverable phase of metal.

Acronyms:

µg/L = micrograms per liter
CAS = Chemical Abstracts Service
DDx = dichlorodiphenyltrichloroethane and its derivatives
EPA = U.S. Environmental Protection Agency
FOD = frequency of detection
NA = Not applicable
ND = not detected
mg/L = milligrams per liter
NA = Not applicable

ND = not detected
ng/L = nanograms per liter
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
pg/L = picograms per liter
Qual = qualifier
TEQ = toxicity equivalence

Table 2. Summary Statistics for 2018 PDI Storm-Flow Sampling Event

Chemical	CAS Number	Record of Decision Cleanup Level	Units	Frequency of Detection (a)	FOD % (a)	Minimum Detected Concentration (b)	Qual	Maximum Detected Concentration (b)	Qual	Mean Detected Concentration (c)	Median Detected Concentration (c)	Location of Maximum Concentration	Minimum Reporting Limit (d)	Maximum Reporting Limit (d)
Dioxins and Furans														
TCDD-TEQ (PDI) (e)	T_DF_TEQ (PDI)	0.0005	pg/L	7 : 7	100%	0.0379		0.0958		0.0646	0.0609	T02	--	--
Polychlorinated Biphenyls (PCBs)														
Total PCBs (PDI) (e)	T_PCBCg (PDI)	6.4	pg/L	7 : 7	100%	95.5		253		175	188	T03	--	--
Pesticides														
DDD	T_DDD (PDI)	0.031	ng/L	7 : 7	100%	0.0148		0.0386		0.027	0.0312	T02	--	--
DDE	T_DDE (PDI)	0.018	ng/L	7 : 7	100%	0.0252		0.0565		0.033	0.0295	T02	--	--
DDT	T_DDT (PDI)	0.022	ng/L	7 : 7	100%	0.00993		0.0422		0.022	0.0169	T02	--	--
DDx (PDI)	T_DDx (PDI)	10	ng/L	7 : 7	100%	0.0569		0.137		0.0813	0.073	T02	--	--
Total Chlordanes (PDI) (e)	T_Clrdn (PDI)	0.081	ng/L	7 : 7	100%	0.0129		0.0213		0.0161	0.0144	T05	--	--
Aldrin	309-00-2	0.00077	ng/L	7 : 7	100%	0.000373	J	0.0011	J	0.000601	0.000523	T05	--	--
Semivolatile Organics														
Hexachlorobenzene	118-74-1	0.029	ng/L	7 : 7	100%	0.0268	J	0.0376	J	0.0306	0.03	T05	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)														
BaP-TEQ (PDI) (e)	T_BaP-TEQ (PDI)	0.12	ng/L	7 : 7	100%	0.188		0.827		0.423	0.359	T02	--	--
Inorganics (Dissolved) (f)														
Arsenic	7440-38-2	0.018 (g)	µg/L	7 : 7	100%	0.48	J	0.63	J	0.54	0.52	T02	--	--
Chromium	7440-47-3	100	µg/L	5 : 7	71%	0.18	J	0.39	J	0.26	0.22	T01	0.4	0.4
Copper	7440-50-8	2.74	µg/L	6 : 7	86%	0.6	J	0.98	J	0.74	0.72	T06	2	2
Zinc	7440-66-6	36.5	µg/L	4 : 7	57%	2.4	J	2.8	J	2.6	2.625	T07	7	7
Inorganics (Total) (f)														
Arsenic	7440-38-2	0.018 (g)	µg/L	7 : 7	100%	0.44	J	0.61	J	0.53	0.53	T05	--	--
Chromium	7440-47-3	100	µg/L	6 : 7	86%	0.21	J	0.35	J	0.28	0.295	T02	0.4	0.4
Copper	7440-50-8	2.74	µg/L	5 : 7	71%	0.62	J	0.79	J	0.69	0.68	T02	2	2
Tri-n-butyltin	36643-28-4	0.063 (g)	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	0.05	0.05
Zinc	7440-66-6	36.5	µg/L	6 : 7	86%	1.9	J	4	J	2.8	2.75	T04	7	7
Semivolatile Organics														
Bis(2-ethylhexyl)phthalate	117-81-7	0.2	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	0.94	1
MCPP	93-65-2	16	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	1.1	1.2
Pentachlorophenol (ARI)	87-86-5	0.03	µg/L	1 : 7	14%	0.022	J	0.022	J	0.022	0.022	T05	0.025	0.027
Pentachlorophenol (Kelso)	87-86-5	0.03	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	0.94	1
Ethylbenzene	100-41-4	7.3	µg/L	0 : 21	0%	ND		ND		ND	ND	ND	3	3
Physical Parameters														
Dissolved Organic Carbon	DOC	NA	mg/L	8 : 7	100%	1.7	J	2.3	J	1.97	2.01	T07	--	--
Total Dissolved Solids	TDS	NA	mg/L	7 : 7	100%	37		78		56	55	T03	--	--
Total Organic Carbon	TOC	NA	mg/L	7 : 7	100%	1.4	J	2.27	J	1.79	1.7	T04	--	--
Total Suspended Solids	TSS	NA	mg/L	3 : 7	43%	2.6		3.6		3	2.8	T02	2	2

Notes:

a. FOD is defined as the number of detects out of the total number of samples.

b. Minimum/maximum detected concentration; associated data flags shown in Qual column.

    J = The chemical was positively identified; however, the associated numerical value is an estimated concentration.

    JN = The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

    +/- = Indicates the result may be biased high/low.

c. Arithmetic mean and median calculated using detected results only.

d. Lab Reporting Limits are shown where the frequency of detection is less than 100%.

e. Totals and TEQs were calculated using EPA Region 10's 12/12/2017 data summation rules for the PDI, with clarifications in AECOM's

    8/31/2018 memorandum (see Appendix C.3).

f. CULs for metals are based on the dissolved phase unless otherwise indicated. Dissolved phase CULs conservatively compared to total recoverable and dissolved phase.

g. CUL based on total recoverable phase of metal.

Acronyms:

µg/L = micrograms per liter

CAS = Chemical Abstracts Service

DDx = dichlorodiphenyltrichloroethane and its derivatives

EPA = U.S. Environmental Protection Agency

FOD = frequency of detection

mg/L = milligrams per liter

NA = Not applicable

ND = not detected

ng/L = nanograms per liter

PCB = polychlorinated biphenyl

PDI = Pre-Remedial Design Investigation

pg/L = picograms per liter

Qual = qualifier

TEQ = toxicity equivalence

Table 3. Summary Statistics for 2019 PDI High-Flow Sampling Event

Chemical	CAS Number	Record of Decision Cleanup Level	Units	Frequency of Detection (a)	FOD % (a)	Minimum Detected Concentration (b)	Qual	Maximum Detected Concentration (b)	Qual	Mean Detected Concentration (c)	Median Detected Concentration (c)	Location of Maximum Concentration	Minimum Reporting Limit (d)	Maximum Reporting Limit (d)
Dioxins and Furans														
TCDD-TEQ (PDI) (e)	T_DF_TEQ (PDI)	0.0005	pg/L	7 : 7	100%	0.0355		0.12		0.0647	0.0601	T04	--	--
Polychlorinated Biphenyls (PCBs)														
Total PCBs (PDI) (e)	T_PCBCg (PDI)	6.4	pg/L	7 : 7	100%	89.6		183		133	123	T04	--	--
Pesticides														
DDD	T_DDD (PDI)	0.031	ng/L	7 : 7	100%	0.0309		0.108		0.0599	0.0617	T04	--	--
DDE	T_DDE (PDI)	0.018	ng/L	7 : 7	100%	0.0677		0.171		0.133	0.131	T02	--	--
DDT	T_DDT (PDI)	0.022	ng/L	7 : 7	100%	0.084		0.279		0.197	0.223	T03	--	--
DDx (PDI)	T_DDx (PDI)	10	ng/L	7 : 7	100%	0.183		0.505		0.39	0.394	T03	--	--
Total Chlordanes (PDI) (e)	T_Clrdn (PDI)	0.081	ng/L	7 : 7	100%	0.0232		0.0512		0.0397	0.0436	T03	--	--
Aldrin	309-00-2	0.00077	ng/L	7 : 7	100%	0.00045	J	0.00174	J	0.00135	0.00157	T05	--	--
Semivolatile Organics														
Hexachlorobenzene	118-74-1	0.029	ng/L	7 : 7	100%	0.0215	J	0.0283	J	0.0256	0.0261	T03, T05	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)														
Total BaP TEQ (PDI) (e)	T_BaP-TEQ (PDI)	0.12	ng/L	7 : 7	100%	0.168		0.388		0.275	0.265	T02	--	--
Inorganics (Dissolved) (f)														
Arsenic	7440-38-2	0.018 (g)	µg/L	7 : 7	100%	0.28	J	0.39	J	0.31	0.3	T06	--	--
Chromium	7440-47-3	100	µg/L	7 : 7	100%	0.37	J	0.75	J	0.49	0.47	T06	--	--
Copper	7440-50-8	2.74	µg/L	7 : 7	100%	1.1	J	1.5	J	1.2	1.2	T06	--	--
Zinc	7440-66-6	36.5	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	7	7
Inorganics (Total) (f)														
Arsenic	7440-38-2	0.018 (g)	µg/L	7 : 7	100%	0.35	J	0.61	J	0.49	0.48	T07	--	--
Chromium	7440-47-3	100	µg/L	7 : 7	100%	0.65		1.9		1.4	1.4	T04, T05	--	--
Copper	7440-50-8	2.74	µg/L	7 : 7	100%	1.4	J	2.6		2.1	2.1	T04	--	--
Tri-n-butyltin	36643-28-4	0.063 (g)	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	0.05	0.05
Zinc	7440-66-6	36.5	µg/L	7 : 7	100%	3.2	J	5.7	J	4.5	4.7	T04	--	--
Semivolatile Organics														
Bis(2-ethylhexyl)phthalate	117-81-7	0.2	µg/L	1 : 7	14%	3.4		3.4		3.4	3.4	T04	0.95	1.1
MCPP	93-65-2	16	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	1.1	1.3
Pentachlorophenol (ARI)	87-86-5	0.03	µg/L	0 : 7	0%	ND		ND		ND	ND	ND	0.025	0.025
Ethylbenzene	100-41-4	7.3	µg/L	0 : 21	0%	ND		ND		ND	ND	ND	3	3
Physical Parameters														
Dissolved Organic Carbon	DOC	NA	mg/L	7 : 7	100%	2.07		3.75		2.65	2.35	T02	--	--
Total Dissolved Solids	TDS	NA	mg/L	7 : 7	100%	31		57		46	49	T03	--	--
Total Organic Carbon	TOC	NA	mg/L	7 : 7	100%	1.83	J	4.31	J	2.96	3.06	T02	--	--
Total Suspended Solids	TSS	NA	mg/L	7 : 7	100%	2.4		9.8		5.7	4.8	T05	--	--

Notes:
a. FOD is defined as the number of detects out of the total number of samples.
b. Minimum/maximum detected concentration; associated data flags shown in Qual column.
　J = The chemical was positively identified; however, the associated numerical value is an estimated concentration.
　JN = The analyte was tentatively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
　+/- = Indicates the result may be biased high/low.
c. Arithmetic mean and median calculated using detected results only.
d. Lab Reporting Limits are shown where the frequency of detection is less than 100%.
e. Totals and TEQs were calculated using EPA Region 10's 12/12/2017 data summation rules for the PDI, with clarifications in AECOM's
　8/31/2018 memorandum (see Appendix C.3).
f. CULs for metals are based on the dissolved phase unless otherwise indicated. Dissolved phase CULs conservatively compared to total recoverable and dissolved phase.
g. CUL based on total recoverable phase of metal.

Acronyms:
µg/L = micrograms per liter
CAS = Chemical Abstracts Service
DDx = dichlorodiphenyltrichloroethane and its derivatives
EPA = U.S. Environmental Protection Agency
FOD = frequency of detection
mg/L = milligrams per liter
NA = Not applicable
ND = not detected

ng/L = nanograms per liter
PCB = polychlorinated biphenyl
PDI = Pre-Remedial Design Investigation
pg/L = picograms per liter
Qual = qualifier
TEQ = toxicity equivalence

Table 4. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions - Low-Flow Sampling Events 2006 vs. 2018

Low-Flow RI Sampling September 4 - 13, 2006		Low-Flow PDI Sampling August 20-25, 2018	
Transect Locations (RM)			
RI Transect ID	**Location**	**PDI Transect ID**	**Location**
W025	RM 2	Transect 1	RM 1.8
W027	Multnomah Channel	Transect 2	Multnomah Channel
W005	RM 4	Transect 3	RM 4
W011	RM 6.3	Transect 4	RM 7
		Transect 5	RM 8.8
W023	RM 11		
		Transect 6	RM 11.8
W024	RM 16	Transect 7	RM 16.2
Transect Compositing Scheme			
RI Transect ID	**Sampling Scheme**	**PDI Transect ID**	
W025	Vertically integrated samples; East, West, Midchannel (navigational channel)	Transect 1	Cross-sectional river (horizontal and vertical composite)
W027	Cross-sectional near bottom and near surface samples	Transect 2	
W005		Transect 3	
W011		Transect 4	
		Transect 5	
W023	Vertically integrated samples; East, West, Midchannel (navigational channel)		
		Transect 6	
W024	Cross-sectional near bottom and near surface samples	Transect 7	
Water Depths Sampled			
RI Transect ID	**Average Sampling Depth (feet)**	**PDI Transect ID**	**Range of Sampling Depths (feet)**
W025	average depth 14.4	Transect 1	3 to 47
W027	average depth 2.5 to 23.0	Transect 2	3 to 33
W005	average depth 2.3 to 46.3	Transect 3	3 to 49
W011	average depth 2.5 to 42.3	Transect 4	4 to 43
		Transect 5	2.5 to 29
W023	average depth 16.4		
W024	average depth 2.5 to 47.9	Transect 6	3 to 57.7
		Transect 7	3 to 86
Average Water Levels (Height at USGS Gage 14211720; feet) during Sampling			
RI Transect ID	**Gage Height (feet) during RI**	**PDI Transect ID**	**Gage Height (feet) during PDI**
W025	2.44 to 2.48	Transect 1	3.18 to 3.31
W027	3.09	Transect 2	3.31 to 3.48
W005	3.08	Transect 3	3.23
W011	3.04	Transect 4	3.23
		Transect 5	2.65
W023	2.48 to 2.71		
W024	2.65	Transect 6	3.31
		Transect 7	3.48
Average Daily Flow during Sampling (cfs) from USGS 14211720			
RI Transect ID	**Range of Flow (cfs) during RI**	**PDI Transect ID**	**Range of Flow (cfs) during PDI**
W025	5,940, 8,990	Transect 1	5,041, 6,534
W027	5,430	Transect 2	5,661, 6,534
W005	6,810	Transect 3	6,795
W011	6,300	Transect 4	6,795
W023	5,940, 6,450	Transect 5	8,697
W024	6,670	Transect 6	6,534
		Transect 7	5,661
Volume Pumped during Sampling			
RI Transect ID	**Volume per sub-sample (liters)**	**PDI Transect ID**	**Total volume (liters)**
W025	378 (E), 427 (M), 518 (W)	Transect 1	422
W027	509 (NS), 507 (NB)	Transect 2	420.5
W005	501 (NS), 510 (NB)	Transect 3	400
W011	503 (NS), 503 (NB)	Transect 4	401.3
		Transect 5	400
W023	505 (E), 511 (M), 516 (W)		
W024	498 (NS), 485 (NB)	Transect 6	405.2
		Transect 7	403.1

Table 4. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions - Low-Flow Sampling Events 2006 vs. 2018

Low-Flow RI Sampling September 4 - 13, 2006		Low-Flow PDI Sampling August 20-25, 2018	
Turbidity During Sampling			
RI Transect ID	**Average turbidity (NTU)**	**PDI Transect ID**	**Average turbidity (NTU)**
W025	1.5	Transect 1	4.7
W027	2.8 to 5.5	Transect 2	4.0
W005	3.6 to 5.1	Transect 3	6.3
W011	3.0 to 4.7	Transect 4	23.9
		Transect 5	4.7
W023	1.7		
W024	0[a] to 2.3	Transect 6	3.7
		Transect 7	2.8
Sample Total Suspended Soilds (mg/L)			
RI Transect ID	**TSS**	**PDI Transect ID**	**TSS**
W025	4 to 8	Transect 1	4.6
W027	6 to 12	Transect 2	3.6
W005	8 to 16	Transect 3	7.8
W011	6 to 15	Transect 4	2.8
		Transect 5	5.8
W023	< 1 to 10		
W024	3	Transect 6	4.2
		Transect 7	2.6
Total Organic Carbon (mg/L)			
RI Transect ID	**TOC**	**PDI Transect ID**	**TOC**
W025	ND (<1.8)	Transect 1	2.0
W027	ND (<1.7)	Transect 2	2.0
W005	ND (<1.7)	Transect 3	2.2
W011	ND (<1.8)	Transect 4	2.4
		Transect 5	1.4
W023	ND (< 1.9)		
W024	ND (<1.7)	Transect 6	2.8
		Transect 7	4.5
Dissolved Organic Carbon (mg/L)			
RI Transect ID	**DOC**	**PDI Transect ID**	**DOC**
W025	ND (<1.8)	Transect 1	2.3
W027	ND (<1.5)	Transect 2	2.0
W005	ND (<1.4)	Transect 3	1.9
W011	ND (<1.5)	Transect 4	2.2
		Transect 5	1.8
W023	ND (<1.7)		
W024	ND (<1.6)	Transect 6	3.2
		Transect 7	5.0
Analytical Methods			
Analyte Group	**Method per RI**	**Method per PDI**	
PCB	AXYS SOP MLA-010	EPA 1668A	
DDx	AXYS SOP MLA-028	MLA-028/EPA1699	
PAHs	AXYS SOP MLA-021	AXYS SOP MLA-021	
D/F	AXYS SOP MLA-017	EPA 1613B	

Notes:

a. Turbidity data in the FSR from the RI event were reported as negative values, down to -2.9 (minimum).

Gage height, stream velocity, and river flow obtained from USGS gaging station:

https://waterdata.usgs.gov/nwis/uv?site_no=14211720

AXYS SOPs are for HRGC/HRMS (high resolution gas chromatography/high resolution mass spectrometry)

Acronyms:

cfs = cubic feet per second

D/F = dioxin and furan

DDx = dichlorodiphenyltrichloroethane and its derivatives

DOC = dissolved organic carbon

E = east bank

ID = identifier

M = midchannel

mg/L = milligrams per liter

NB = near bottom

ND = non-detect

NS = near surface

NTU = nephelometric turbidity unit

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

PDI = Pre-Remedial Design Investigation

RI = Remedial Investigation

RM = river mile

SOP = Standard Operating Procedure

TSS = total suspended solids

USGS = U.S. Geological Survey

W = west bank

Table 5. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions -
Storm-Flow Sampling Events 2006 vs. 2018

Storm-Flow RI Sampling November 1 to 5, 2006		Storm-Flow PDI Sampling November 27 to December 1, 2018	
Transect Locations (RM)			
RI Transect/Sample Location ID	**Location**	**PDI Transect ID**	**Location**
W025	RM 2	Transect 1	RM 1.8
W026[a]	RM 2.2	Transect 2	Multnomah Channel
W027	Multnomah Channel		
W028[a]	RM 3.6		
W005	RM 4	Transect 3	RM 4
W029[a]	RM 4.5		
W030[a]	RM 5.5		
W031[b]	RM 6.1		
W011	RM 6.3		
W032	RM 6.9		
W033	RM 7	Transect 4	RM 7
W034[b]	RM 7.4		
W035	RM 8.5		
W036[a]	RM 8.6	Transect 5	RM 8.8
W037[a]	RM 9.6		
W038[a]	RM 9.9		
W023	RM 11		
		Transect 6	RM 11.8
W024	RM 16	Transect 7	RM 16.2
Transect Compositing Scheme			
RI Transect/Sample Location ID	**Sampling Scheme**	**PDI Transect ID**	
W025	Vertically integrated transect samples; East, West, Midchannel (navigational channel)	Transect 1	
W026[a]	Single point NB/NS	Transect 2	
W027	Cross-sectional NB and NS transects		
W028[a]	Single point NB/NS		
W005	Cross-sectional NB and NS transects	Transect 3	
W029[a]	Single point NB/NS		
W030[a]			
W031[b]			
W011	Cross-sectional NB and NS transects		Cross-sectional river (horizontal and vertical composite)
W032	Single point NB/NS		
W033		Transect 4	
W034[b]			
W035			
W036[a]		Transect 5	
W037[a]			
W038[a]			
W023	Vertically integrated transect samples; East, West, Midchannel (navigational channel)		
		Transect 6	
W024	Cross-sectional NB and NS transects	Transect 7	
Water Depths Sampled			
RI Transect/Sample Location ID	**Sampling Depth (feet)**	**PDI Transect ID**	**Range of Sampling Depths (feet)**
W025	10.2 to 45.9	Transect 1	3 to 49
W026[a]	3.3 to 32	Transect 2	3 to 31
W027	12.5 to 31.7		
W028[a]	3.3 to 32.7		
W005	3.3 to 50.5	Transect 3	3 to 55
W029[a]	3.3 to 16.5		
W030[a]	3.3 to 23.8		
W031[b]	3.3 to 16.5		
W011	3.3 to 51.5		
W032	3.3 to 29.4		
W033	3.3 to 14.5	Transect 4	3 to 44
W034[b]	5 to 23.4		
W035	5 to 31.4		
W036[a]	2.6 to 22.4	Transect 5	3 to 30
W037[a]	3.3 to 12.5		
W038[a]	5 to 8.9		
W023	28.1 to 48.8		
		Transect 6	3 to 64
W024	4.6 to 78.2	Transect 7	3 to 86

Table 5. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions - Storm-Flow Sampling Events 2006 vs. 2018

Storm-Flow RI Sampling November 1 to 5, 2006		Storm-Flow PDI Sampling November 27 to December 1, 2018	
Average Water Levels (Height at USGS Gage 14211720; feet) during Sampling			
RI Transect/Sample Location ID	**Gage Height (feet) during RI**	**PDI Transect ID**	**Gage Height (feet) during PDI**
W025	2.94	Transect 1	4.25
W026[a]	3.79	Transect 2	3.78
W027	3.79		
W028[a]	3.79		
W005	3.79	Transect 3	4.40
W029[a]	3.76		
W030[a]	3.79		
W031[b]	4.68		
W011	3.76		
W032	4.68		
W033	3.76	Transect 4	3.66
W034[b]	3.79		
W035	4.68		
W036[a]	3.79	Transect 5	4.40
W037[a]	4.68		
W038[a]	4.68		
W023	2.94		
		Transect 6	3.78
W024	3.76	Transect 7	4.25
Average Daily Flow during Sampling (cfs) from USGS 14211720			
RI Transect/Sample Location ID	**Range of Flow (cfs) during RI**	**PDI Transect ID**	**Range of Flow (cfs) during PDI**
W025	16,200	Transect 1	21,879
W026[a]	20,300	Transect 2	27,407
W027	20,300		
W028[a]	20,300		
W005	20,300	Transect 3	16,780
W029[a]	16,300		
W030[a]	20,300		
W031[b]	26,200		
W011	16,300		
W032	26,200		
W033	16,300	Transect 4	25,077
W034[b]	20,300		
W035	26,200		
W036[a]	20,300	Transect 5	16,780
W037[a]	26,200		
W038[a]	26,200		
W023	16,200		
		Transect 6	27,407
W024	16,300	Transect 7	21,879
Rainfall during Sampling (inches)			
RI Transect/Sample Location ID	**Daily rainfall**	**PDI Transect ID**	**Daily Rainfall**
W025	1.11	Transect 1	0.36
W026[a]	0.56	Transect 2	0.56
W027	0.56		
W028[a]	0.56		
W005	0.56	Transect 3	0.57
W029[a]	0.30		
W030[a]	0.56		
W031[b]	1.12		
W011	0.30		
W032	1.12		
W033	0.30	Transect 4	0.08
W034[b]	0.56		
W035	1.12		
W036[a]	0.56	Transect 5	0.57
W037[a]	1.12		
W038[a]	1.12		
W023	1.11		
		Transect 6	0.56
W024	0.30	Transect 7	0.36
Total for event	3.09		1.57

Table 5. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions - Storm-Flow Sampling Events 2006 vs. 2018

Storm-Flow RI Sampling November 1 to 5, 2006		Storm-Flow PDI Sampling November 27 to December 1, 2018	
Volume Pumped during Sampling			
RI Transect/Sample Location ID	**Volume per sub-sample (liters)**	**PDI Transect ID**	**Total Volume (liters)**
W025	103 (E), 101 (M), 100 (W)	Transect 1	151
W026[a]	35 (NB), 34 (NS)	Transect 2	150
W027	106 (NB), 104 (NS)		
W028[a]	35 (NB), 34 (NS)		
W005	108 (NB), 108 (NS)	Transect 3	150
W029[a]	33 (NB), 33 (NS)		
W030[a]	35 (NB), 40 (NS)		
W031[b]	51 (NB), 50 (NS)		
W011	116 (NB,) 111 (NS)		
W032	106 (NB), 106 (NS)		
W033	100 (NB), 101 (NS)	Transect 4	150
W034[b]	53 (NB), 55 (NS)		
W035	107 (NB), 108 (NS)		
W036[a]	36 (ND), 40 (NS)	Transect 5	225
W037[a]	31 (NB), 35 (NS)		
W038[a]	37 (NB), 38 (NS)		
W023	101 (E), 106 (M), 121 (W)		
		Transect 6	150
W024	109 (NB), 121 (NS)	Transect 7	150
Turbidity During Sampling			
RI Transect/Sample Location ID	**Average turbidity (NTU)**	**PDI Transect ID**	**Average Turbidity (NTU)**
W025	1.26	Transect 1	1.43
W026[a]	2.64	Transect 2	3.01
W027	1.68		
W028[a]	2.12		
W005	2.51	Transect 3	1.45
W029[a]	1.23		
W030[a]	2.3		
W031[b]	1.83		
W011	1.83 to 3.47		
W032	2.74		
W033	2.02 to 2.13	Transect 4	3.07
W034[b]	2.03		
W035	5.55		
W036[a]	2.58	Transect 5	0.94
W037[a]	1.68		
W038[a]	6.51		
W023	1.22		
		Transect 6	3.07
W024	3.08 to 3.38	Transect 7	2.13
Sample Total Suspended Soilds (mg/L)			
RI Transect/Sample Location ID	**TSS**	**PDI Transect ID**	**TSS**
W025	5	Transect 1	< 2.0
W026[a]	4 to 7	Transect 2	3.6
W027	3 to 4		
W028[a]	4		
W005	6	Transect 3	< 2.0
W029[a]	5 to 6		
W030[a]	2 to 4		
W031[b]	2 to 4		
W011	3 to 5		
W032	3 to 4		
W033	4 to 6	Transect 4	2.8
W034[b]	3 to 4		
W035	3 to 5		
W036[a]	4 to 5	Transect 5	< 2.0
W037[a]	3		
W038[a]	4 to 5		
W023	<1 to 4		
		Transect 6	2.6
W024	5	Transect 7	< 2.0

Table 5. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions - Storm-Flow Sampling Events 2006 vs. 2018

Storm-Flow RI Sampling November 1 to 5, 2006		Storm-Flow PDI Sampling November 27 to December 1, 2018	
Total Organic Carbon (mg/L)			
RI Transect/Sample Location ID	**TOC**	**PDI Transect ID**	**TOC**
W025	5	Transect 1	1.4
W026[a]	1.8 to 2	Transect 2	2.0
W027	2		
W028[a]	1.9		
W005	1.9 to 2	Transect 3	1.5
W029[a]	1.7 to 1.8		
W030[a]	1.9 to 2		
W031[b]	1.9 to 2		
W011	1.7		
W032	1.9 to 2		
W033	1.8 to 1.9	Transect 4	2.3
W034[b]	1.9 to 1.9		
W035	1.9 to 1.9		
W036[a]	2 to 2.1	Transect 5	1.5
W037[a]	2.1 to 2.1		
W038[a]	2 to 2.1		
W023	1.8 to 2.2		
		Transect 6	2.2
W024	5	Transect 7	1.7
Dissolved Organic Carbon (mg/L)			
RI Transect/Sample Location ID	**DOC**	**PDI Transect ID**	**DOC**
W025	1.4 to 1.5	Transect 1	1.8
W026[a]	1.4 to 1.6	Transect 2	1.8
W027	1.4 to 1.5		
W028[a]	1.5 to 1.7		
W005	1.5	Transect 3	1.7
W029[a]	1.4 to 1.6		
W030[a]	1.4 to 1.5		
W031[b]	1.5 to 1.7		
W011	1.4		
W032	1.5 to 1.5		
W033	1.4 to 1.5	Transect 4	2.1
W034[b]	1.5 to 1.5		
W035	1.4 to 1.5		
W036[a]	1.5 to 1.6	Transect 5	2.1
W037[a]	1.6 to 1.7		
W038[a]	1.5 to 1.6		
W023	1.4 to 1.6		
		Transect 6	2.0
W024	1.5	Transect 7	2.3
Analytical Methods			
Analyte Group	**Method per RI**	**Method per PDI**	
PCB	AXYS SOP MLA-010	EPA 1668A	
DDx	AXYS SOP MLA-028	MLA-028/EPA1699	
PAHs	AXYS SOP MLA-021	AXYS SOP MLA-021	
D/F	AXYS SOP MLA-017	EPA 1613B	

Notes:

a. Analyzed for PCBs, but not D/F, pesticides or PAHs.

b. Analyzed for PCBs and pesticides, but not D/F or PAHs.

Gage height, stream velocity, and river flow obtained from USGS gaging station:

https://waterdata.usgs.gov/nwis/uv?site_no=14211720

AXYS SOPs are for HRGC/HRMS (high resolution gas chromatography/high resolution mass spectrometry)

Acronyms:

cfs = cubic feet per second	NTU = nephelometric turbidity unit
D/F = dioxin and furan	PAH = polycyclic aromatic hydrocarbon
DDx = dichlorodiphenyltrichloroethane and its derivatives	PCB = polychlorinated biphenyl
DOC = dissolved organic carbon	PDI = Pre-Remedial Design Investigation
E = east bank	RI = Remedial Investigation
ID = identifier	RM = river mile
M = midchannel	SOP = Standard Operating Procedure
mg/L = milligrams per liter	TSS = total suspended solids
NB = near bottom	USGS = U.S. Geological Survey
ND = non-detect	W = west bank
NS = near surface	

**Table 6. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions -
High-Flow Sampling Events 2007 vs. 2019**

High-Flow RI Sampling January 17-18, 2007 and February 21 - March 10, 2007		High-Flow PDI Sampling January 25-27, 2019 and February 17-18, 2019	
Transect Locations (RM)			
RI Transect/Sample Location ID	**Location**	**PDI Transect ID**	**Location**
W025	RM 2	Transect 1	RM 1.8
W026[a]	RM 2.2	Transect 2	Multnomah Channel
W027	Multnomah Channel		
W028[a]	RM 3.6		
W005	RM 4	Transect 3	RM 4
W029[a]	RM 4.5		
W030[a]	RM 5.5		
W031[b]	RM 6.1		
W011	RM 6.3		
W032	RM 6.9		
W033	RM 7	Transect 4	RM 7
W034[b]	RM 7.4		
W035	RM 8.5		
W036[a]	RM 8.6	Transect 5	RM 8.8
W037[a]	RM 9.6		
W038[a]	RM 9.9		
W023	RM 11		
		Transect 6	RM 11.8
W024	RM 16	Transect 7	RM 16.2
Transect Compositing Scheme			
RI Transect/Sample Location ID	**Sampling Scheme**	**PDI Transect ID**	
W025	Vertically integrated transect samples; East, West, Midchannel (navigational channel)	Transect 1	Cross-sectional river (horizontal and vertical composite)
W026[a]	Single point NB/NS	Transect 2	
W027	Cross-sectional NB and NS transects		
W028[a]	Single point NB/NS		
W005	Cross-sectional NB and NS transects	Transect 3	
W029[a]	Single point NB/NS		
W030[a]			
W031[b]			
W011	Cross-sectional NB and NS transects		
W032			
W033	Single point NB/NS	Transect 4	
W034[b]			
W035			
W036[a]		Transect 5	
W037[a]			
W038[a]			
W023	Vertically integrated transect samples; East, West, Midchannel (navigational channel)		
		Transect 6	
W024	Cross-sectional NB and NS transects	Transect 7	
Water Depths Sampled			
RI Transect/Sample Location ID	**Sampling Depth (feet)**	**PDI Transect ID**	**Range of Sampling Depths (feet)**
W025	25.5 to 51.4	Transect 1	3.0 to 50.0
W026[a]	3.0 to 32.8	Transect 2	3.0 to 32.0
W027	5.1 to 35.7		
W028[a]	5.2 to 28.4		
W005	5.0 to 54.8	Transect 3	3.3 to 53.0
W029[a]	5.0 to 25.2		
W030[a]	4.2 to 27.9		
W031[b]	5.2 to 27.7		
W011	4.5 to 55.1		
W032	not measured		
W033	3.0 to 17.1	Transect 4	1.0 to 47.0
W034[b]	1.8 to 25.7		
W035	1.4 to 31.0		
W036[a]	4.0 to 23.5	Transect 5	3.1 to 30.7
W037[a]	2.7 to 21.1		
W038[a]	5.1 to 14.6		
W023	27.7 to 43.3		
		Transect 6	3.9 to 62.0
W024	3.9 to 66.7	Transect 7	3.8 to 85.0

Table 6. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions -
High-Flow Sampling Events 2007 vs. 2019

High-Flow RI Sampling January 17-18, 2007 and February 21 - March 10, 2007		High-Flow PDI Sampling January 25-27, 2019 and February 17-18, 2019	
Average Water Levels (Height at USGS Gage 14211720; feet) during Sampling			
RI Transect/Sample Location ID	**Gage Height (feet) during RI**	**PDI Transect ID**	**Gage Height (feet) during PDI**
W025	5.76	Transect 1	5.39
W026[a]	5.79	Transect 2	5.39
W027	5.8		
W028[a]	6.12		
W005	6.16	Transect 3	3.40
W029[a]	5.8		
W030[a]	6.12		
W031[b]	5.22		
W011	6.28		
W032	7.06		
W033	5.79	Transect 4	1.42
W034[b]	5.22		
W035	5.63		
W036[a]	5.7	Transect 5	1.42
W037[a]	5.66		
W038[a]	6.53		
W023	6.26		
		Transect 6	4.29
W024	6.57	Transect 7	4.94
Average Daily Flow during Sampling (cfs) from USGS 14211720			
RI Transect/Sample Location ID	**Range of Flow (cfs) during RI**	**PDI Transect ID**	**Range of Flow (cfs) during PDI**
W025	52,233	Transect 1	52,897
W026[a]	69,400	Transect 2	52,897
W027	70,200		
W028[a]	62,500		
W005	64,450	Transect 3	54,339
W029[a]	65,300		
W030[a]	62,500		
W031[b]	55,400		
W011	63,650		
W032	57,100		
W033	69,400	Transect 4	55,781
W034[b]	55,400		
W035	63,900		
W036[a]	72,600	Transect 5	55,781
W037[a]	54,600		
W038[a]	60,100		
W023	65,233		
		Transect 6	45,706
W024	48,500	Transect 7	52,099
Volume Pumped during Sampling			
RI Transect/Sample Location ID	**Volume per sub-sample (liters)**	**PDI Transect ID**	**Total volume (liters)**
W025	452 (E), 503 (M), 504 (W)	Transect 1	400
W026[a]	170 (NB), 174 (NS)	Transect 2	400
W027	500 (NB), 502 (NS)		
W028[a]	168 (NB), 170 (NS)		
W005	500 (NB), 500 (NS)	Transect 3	400
W029[a]	463 (NB), 515 (NS)		
W030[a]	183 (NB), 169 (NS)		
W031[b]	251 (NB), 256 (NS)		
W011	500 (NB,) 500 (NS)		
W032	425 (NB), 463 (NS)		
W033	500 (NB), 513 (NS)	Transect 4	402
W034[b]	169 (NB), 169 (NS)		
W035	501 (NB), 501 (NS)		
W036[a]	179 (ND), 180 (NS)	Transect 5	422
W037[a]	176 (NB), 200 (NS)		
W038[a]	510 (NB), 515 (NS)		
W023	501 (E), 508 (M), 306 (W)		
		Transect 6	400
W024	300 (NB), 302 (NS)	Transect 7	400

Table 6. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions -
High-Flow Sampling Events 2007 vs. 2019

High-Flow RI Sampling January 17-18, 2007 and February 21 - March 10, 2007		High-Flow PDI Sampling January 25-27, 2019 and February 17-18, 2019	
Turbidity During Sampling			
RI Transect/Sample Location ID	**Average turbidity (NTU)**	**PDI Transect ID**	**Average turbidity (NTU)**
W025	7.2 to 11.6	Transect 1	1.4
W026[a]	17.6 to 18.4	Transect 2	3.1
W027	23.7 to 27.1		
W028[a]	21.5 to 21.6		
W005	17.4 to 19.3	Transect 3	1.4
W029[a]	13.8 to 15.8		
W030[a]	21.9 to 21.9		
W031[b]	17.0		
W011	21.9 to 24.0		
W032	not measured		
W033	18.3 to 19.1	Transect 4	3.1
W034[b]	15.5 to 17.5		
W035	14.4 to 15.9		
W036[a]	27.8 to 28.1	Transect 5	0.9
W037[a]	0[c]		
W038[a]	9.5 to 13.1		
W023	18.0 to 22.2		
		Transect 6	11.4
W024	8.5 to 9.3	Transect 7	16.6
Sample Total Suspended Soilds (mg/L)			
RI Transect/Sample Location ID	**TSS**	**PDI Transect ID**	**TSS**
W025	10	Transect 1	4.4
W026[a]	13	Transect 2	4.8
W027	32.5		
W028[a]	19		
W005	16	Transect 3	6.8
W029[a]	16.5		
W030[a]	19.5		
W031[b]	38.5		
W011	20		
W032	16		
W033	20.5	Transect 4	7.8
W034[b]	16.5		
W035	16		
W036[a]	31	Transect 5	9.8
W037[a]	22.5		
W038[a]	17.5		
W023	17		
		Transect 6	2.4
W024	12.5	Transect 7	4.2
Total Organic Carbon (mg/L)			
RI Transect/Sample Location ID	**TOC**	**PDI Transect ID**	**TOC**
W025	1.6	Transect 1	3.06
W026[a]	1.9	Transect 2	4.31
W027	2.2		
W028[a]	2.1		
W005	1.9	Transect 3	2.82
W029[a]	2.1	1.4	
W030[a]	2.1	2.2	
W031[b]	1.9		
W011	1.95		
W032	1.9		
W033	1.9	Transect 4	3.38
W034[b]	2		
W035	2		
W036[a]	2.2	Transect 5	3.12
W037[a]	2		
W038[a]	1.8		
W023	1.8		
		Transect 6	1.83
W024	1.4	Transect 7	2.17

Table 6. Comparison of High-Volume Surface Water Sampling Methodologies and Field Conditions - High-Flow Sampling Events 2007 vs. 2019

High-Flow RI Sampling January 17-18, 2007 and February 21 - March 10, 2007		High-Flow PDI Sampling January 25-27, 2019 and February 17-18, 2019	
Dissolved Organic Carbon (mg/L)			
RI Transect/Sample Location ID	**DOC**	**PDI Transect ID**	**DOC**
W025	1.3	Transect 1	2.67
W026[a]	1.6	Transect 2	3.75
W027	2.3		
W028[a]	1.9		
W005	2.0	Transect 3	2.35
W029[a]	1.7		
W030[a]	1.8		1.3
W031[b]	2.1		2.25
W011	2.1		
W032	1.7		
W033	1.9	Transect 4	3.35
W034[b]	2.0		
W035	2.0		
W036[a]	1.8	Transect 5	2.20
W037[a]	1.7		
W038[a]	1.5		
W023	1.6		
		Transect 6	2.07
W024	1.3	Transect 7	2.15
Analytical Methods			
Analyte Group	**Method per RI**	**Method per PDI**	
PCB	AXYS SOP MLA-010	EPA 1668A	
DDx	AXYS SOP MLA-028	MLA-028/EPA1699	
PAHs	AXYS SOP MLA-021	AXYS SOP MLA-021	
D/F	AXYS SOP MLA-017	EPA 1613B	

Notes:

a. Analyzed for PCBs, but not D/F, pesticides or PAHs.

b. Analyzed for PCBs and pesticides, but not D/F or PAHs.

c. Turbidity data in the FSR from the RI event were reported as negative values, down to -3.5 (minimum).

Gage height, stream velocity, and river flow obtained from USGS gaging station:

https://waterdata.usgs.gov/nwis/uv?site_no=14211720

AXYS SOPs are for HRGC/HRMS (high resolution gas chromatography/high resolution mass spectrometry)

Acronyms:

cfs = cubic feet per second

D/F = dioxin and furan

DDx = dichlorodiphenyltrichloroethane and its derivatives

DOC = dissolved organic carbon

E = east bank

ID = identifier

M = midchannel

mg/L = milligrams per liter

NB = near bottom

ND = non-detect

NS = near surface

NTU = nephelometric turbidity unit

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

PDI = Pre-Remedial Design Investigation

RI = Remedial Investigation

RM = river mile

SOP = Standard Operating Procedure

TSS = total suspended solids

USGS = U.S. Geological Survey

W = west bank

Table 7. Comparison of Qualification of High-Volume Surface Water Data - Low-Flow Sampling Events 2006 vs. 2018

Analyte Group	RI - 2006	PDI - 2018
Frequency of Qualification: Dissolved Fraction (XAD)		
Dioxin/furans	44%	29%
Polychlorinated biphenyls (PCBs)	5%	42%
Polycylic aromatic hydrocarbons (PAHs)	9%	84%
DDx	64%	55%
Frequency of Qualification: Particulate Fraction		
Dioxin/furans	45%	53%
Polychlorinated biphenyls (PCBs)	7%	42%
Polycylic aromatic hydrocarbons (PAHs)	18%	98%
DDx	68%	83%
Frequency of Detection: Dissolved Fraction (XAD)		
Dioxin/furans	57.6%	36%
Polychlorinated biphenyls (PCBs)	79.4%	82%
Polycylic aromatic hydrocarbons (PAHs)	44.7%	89%
DDx	96.9%	100%
Frequency of Detection: Particulate Fraction		
Dioxin/furans	81%	73%
Polychlorinated biphenyls (PCBs)	74%	78%
Polycylic aromatic hydrocarbons (PAHs)	51%	100%
DDx	86%	95%
Range of Detection Limits: Dissolved Fraction (XAD)		
Dioxin/furans	0.00104 to 0.0553 pg/L	0.00203 to 0.00385 pg/L
Polychlorinated biphenyls (PCBs)	0.001 to 10.8 pg/L	0.00203 to 0.033 pg/L
Polycylic aromatic hydrocarbons (PAHs)	0.101 to 0.0321 ng/L	0.00498 to 0.0113 ng/L
DDx	0.00257 to 0.00423 ng/L	NA
Range of Detection Limits: Particulate Fraction		
Dioxin/furans	0.0013 to 0.018 pg/L	0.0103 to 0.011 pg/L
Polychlorinated biphenyls (PCBs)	0.001 to 0.806 pg/L	0.0103 to 0.165 pg/L
Polycylic aromatic hydrocarbons (PAHs)	0.056 to 3.56 ng/L	NA
DDx	0.000538 to 0.00548 ng/L	0.000638 to 0.000654 ng/L

Note:

Qualification includes qualifiers of J, JN, J+ or J-.

Acronyms:

DDx = dichlorodiphenyltrichloroethane and its derivatives

NA = Not applicable

ng/L = nanogram per liter

PDI = Pre-Remedial Design Investigation

pg/L = picogram per liter

RI = Remedial Investigation

Table 8. Comparison of Qualification of High-Volume Surface Water Data - Storm-Flow Sampling Events 2006 vs. 2018

Analyte Group	RI - 2006	PDI - 2018
Frequency of Qualification: Dissolved Fraction (XAD)		
Dioxin/furans	14%	10%
Polychlorinated biphenyls (PCBs)	14%	40%
Polycylic aromatic hydrocarbons (PAHs)	13%	59%
DDx	88%	97%
Frequency of Qualification: Particulate Fraction		
Dioxin/furans	36%	63%
Polychlorinated biphenyls (PCBs)	15%	32%
Polycylic aromatic hydrocarbons (PAHs)	39%	86%
DDx	79%	86%
Frequency of Detection: Dissolved Fraction (XAD)		
Dioxin/furans	24%	13%
Polychlorinated biphenyls (PCBs)	53%	75%
Polycylic aromatic hydrocarbons (PAHs)	25%	59%
DDx	88%	97%
Frequency of Detection: Particulate Fraction		
Dioxin/furans	58%	87%
Polychlorinated biphenyls (PCBs)	53%	82%
Polycylic aromatic hydrocarbons (PAHs)	50%	100%
DDx	80%	97%
Range of Detection Limits: Dissolved Fraction (XAD)		
Dioxin/furans	0.005 to 0.127 pg/L	0.00377 to 0.015 pg/L
Polychlorinated biphenyls (PCBs)	0.004 to 16.2 pg/L	0.00377 to 0.261 pg/L
Polycylic aromatic hydrocarbons (PAHs)	0.0438 to 2.54 ng/L	0.00809 to 0.0268 ng/L
DDx	0.00192 to 0.017 ng/L	0.000351 to 0.000351 ng/L
Range of Detection Limits: Particulate Fraction		
Dioxin/furans	0.005 to 1.1 pg/L	0.00386 to 0.00727 pg/L
Polychlorinated biphenyls (PCBs)	0.0047 to 9.55 pg/L	0.00386 to 0.0321 pg/L
Polycylic aromatic hydrocarbons (PAHs)	0.0345 to 107 ng/L	NA
DDx	0.000628 to 0.00733 ng/L	0.000355 to 0.000355 ng/L

Note:

Qualification includes qualifiers of J, JN, J+ or J-.

Acronyms:

DDx = dichlorodiphenyltrichloroethane and its derivatives

NA = Not applicable

ng/L = nanogram per liter

PDI = Pre-Remedial Design Investigation

pg/L = picogram per liter

RI = Remedial Investigation

Table 9. Comparison of Qualification of High-Volume Surface Water Data - High-Flow Sampling Events 2007 vs. 2019

Analyte Group	RI - 2007	PDI - 2019
Frequency of Qualification: Dissolved Fraction (XAD)		
Dioxin/furans	18%	23%
Polychlorinated biphenyls (PCBs)	11% (a)	63%
Polycylic aromatic hydrocarbons (PAHs)	20%	45%
DDx	65%	67%
Frequency of Qualification: Particulate Fraction		
Dioxin/furans	37%	51%
Polychlorinated biphenyls (PCBs)	9%	39%
Polycylic aromatic hydrocarbons (PAHs)	29%	77%
DDx	59%	67%
Frequency of Detection: Dissolved Fraction (XAD)		
Dioxin/furans	31%	29%
Polychlorinated biphenyls (PCBs)	56%	76%
Polycylic aromatic hydrocarbons (PAHs)	58%	45%
DDx	97%	100%
Frequency of Detection: Particulate Fraction		
Dioxin/furans	62%	76%
Polychlorinated biphenyls (PCBs)	70%	74%
Polycylic aromatic hydrocarbons (PAHs)	59%	79%
DDx	97%	100%
Range of Detection Limits: Dissolved Fraction (XAD)		
Dioxin/furans	0.001 to 0.150 pg/L	0.00199 to 0.00573 pg/L
Polychlorinated biphenyls (PCBs)	0.001 to 3.92 pg/L	0.00199 to 0.0368 pg/L
Polycylic aromatic hydrocarbons (PAHs)	0.0123 to 38.2 ng/L	0.00403 to 0.0161 ng/L
DDx	0.00142 to 0.00291 ng/L	NA
Range of Detection Limits: Particulate Fraction		
Dioxin/furans	0.001 to 0.023 pg/L	0.00592 to 0.0183 pg/L
Polychlorinated biphenyls (PCBs)	0.001 to 1.63 pg/L	0.00983 to 1.24 pg/L
Polycylic aromatic hydrocarbons (PAHs)	0.0169 to 1.57 ng/L	0.0508 to 0.0827 ng/L
DDx	0.00113 to 0.0133 ng/L	NA

Notes:

Qualification includes qualifiers of J, JN, J+ or J-.

a. 35 results were rejected (qualified R) and are not included in the frequency of qualification.

Acronyms:

DDx = dichlorodiphenyltrichloroethane and its derivatives

NA = Not applicable

ng/L = nanogram per liter

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

PDI = Pre-Remedial Design Investigation

pg/L = picogram per liter

RI = Remedial Investigation

FIGURES

Legend

- Target Surface Water Locations
- Target Transect Per Field Sampling Plan
- Navigation Channel
- Capped Area (Existing)
- ROD SMA Footprint
- Superfund Site Boundary (RM 1.9 to 11.8)

Note:
1. Contours and Hillshade derived from 2018 Bathymetric Survey
2. Topography map provided by ESRI Basemaps 2018.
3. Locations sampled within 300 feet of target locations. Actual locations presented in Table 6 of the Surface Water FSR, included as Appendix B.5 in the Evaluation Report.

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and

2,000   0   2,000
Feet

PDI Surface Water Sampling Locations
Portland Harbor Superfund Site
Surface Water Sampling Results and Analysis

AECOM   Geosyntec consultants

Figure
1

CK/SEA   June 2019
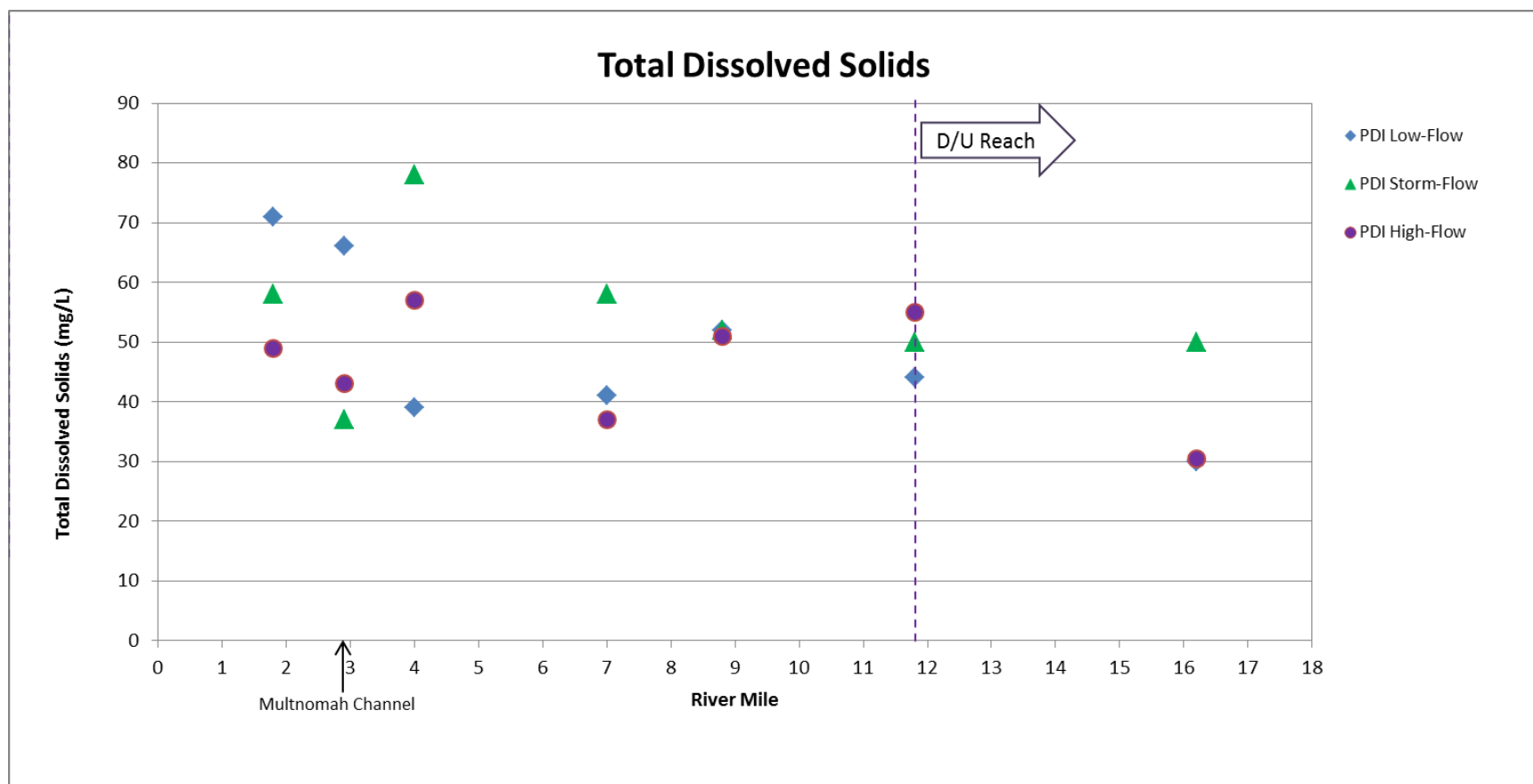
Figure 2. Concentrations of Total Dissolved Solids by River Mile
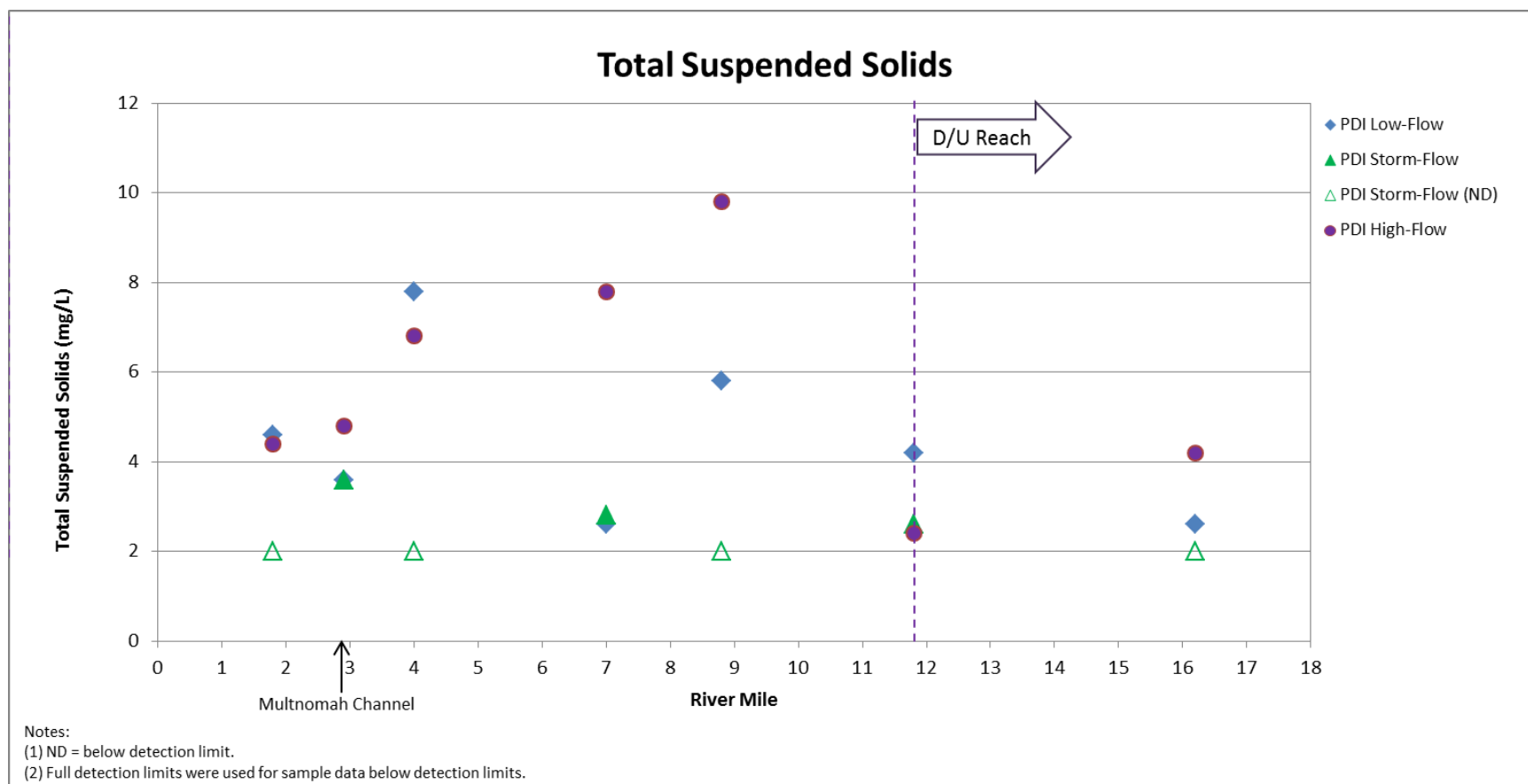
Figure 3. Concentrations of Total Suspended Solids by River Mile
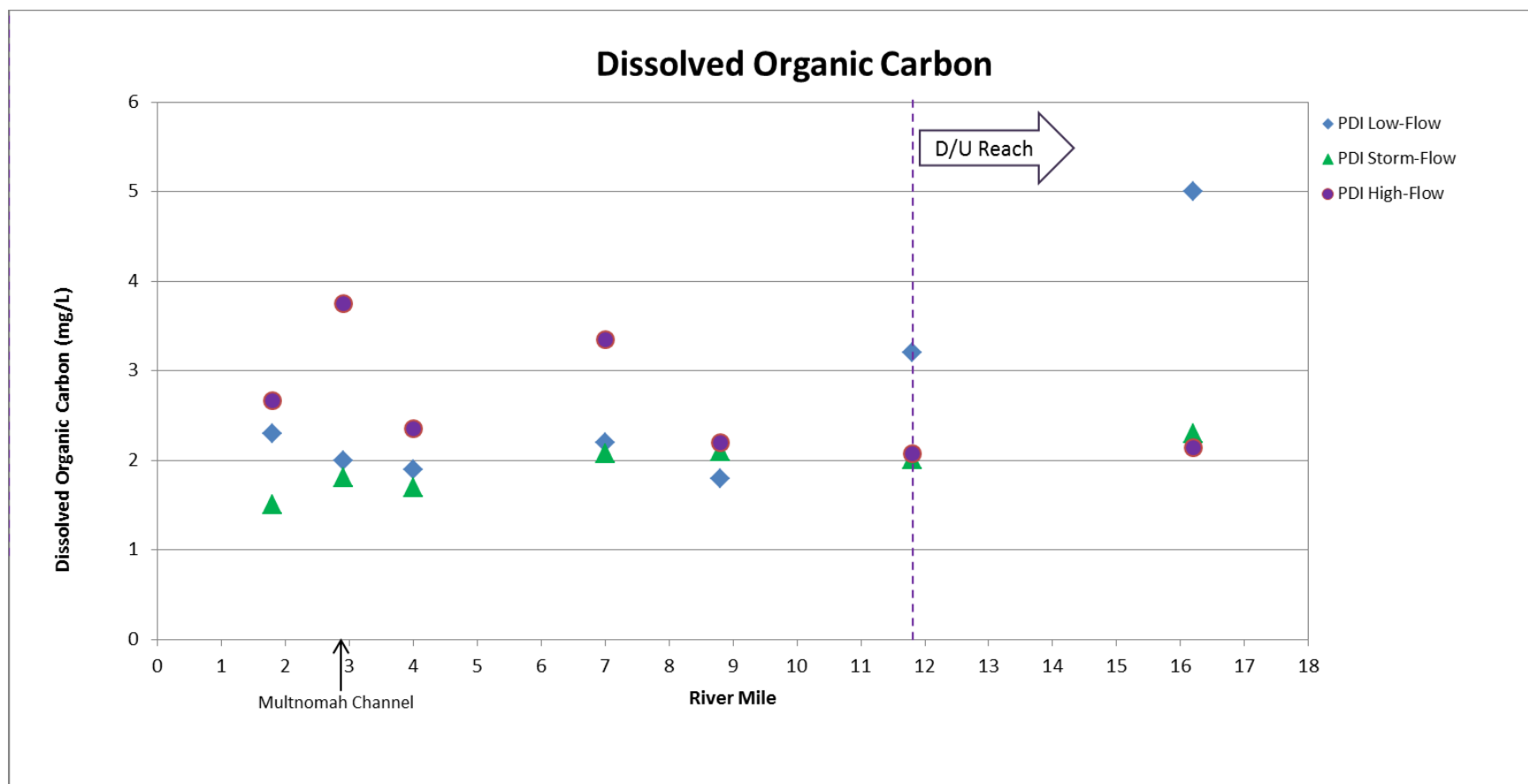
Figure 4. Concentrations of Dissolved Organic Carbon by River Mile
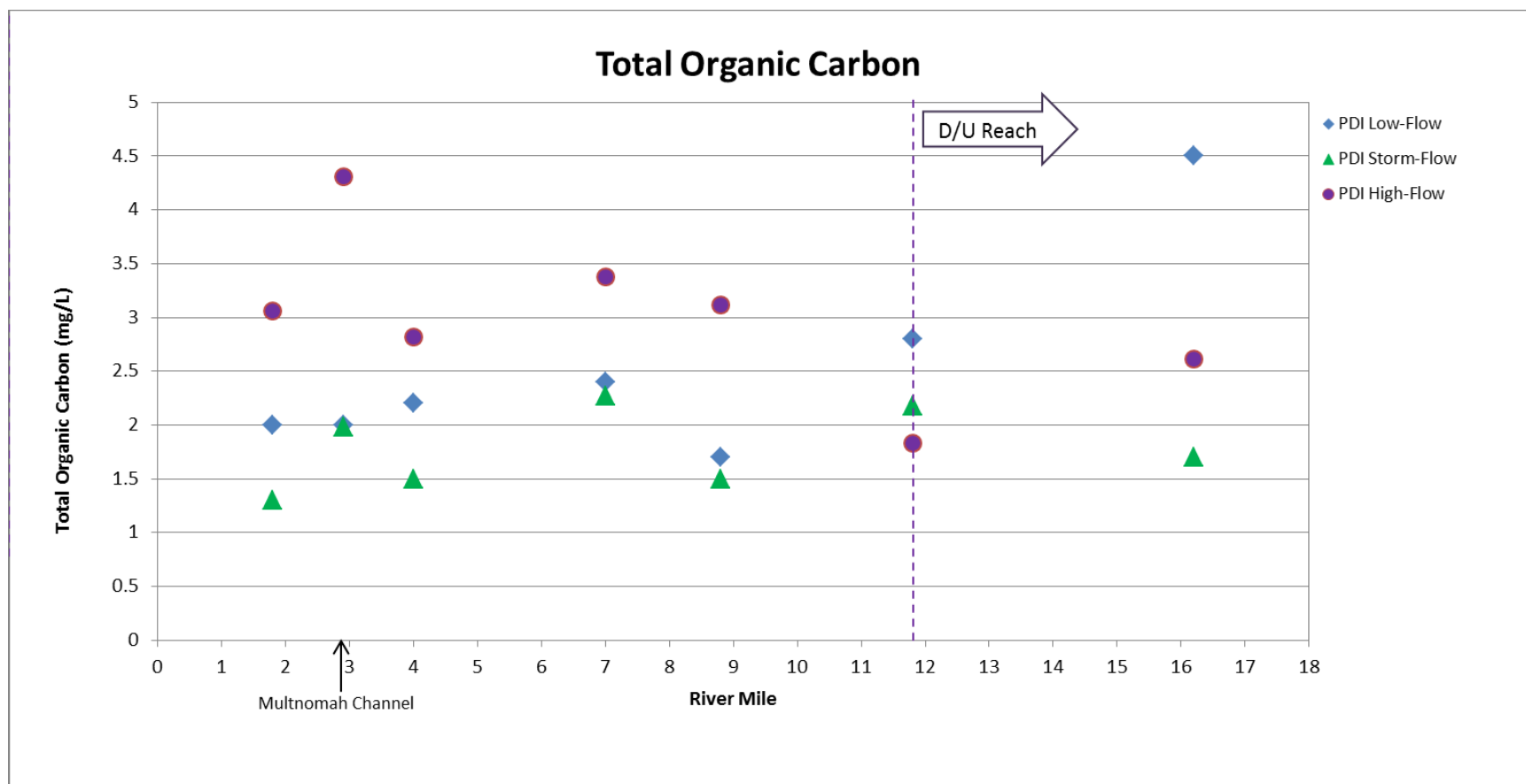
Figure 5. Concentrations of Total Organic Carbon by River Mile
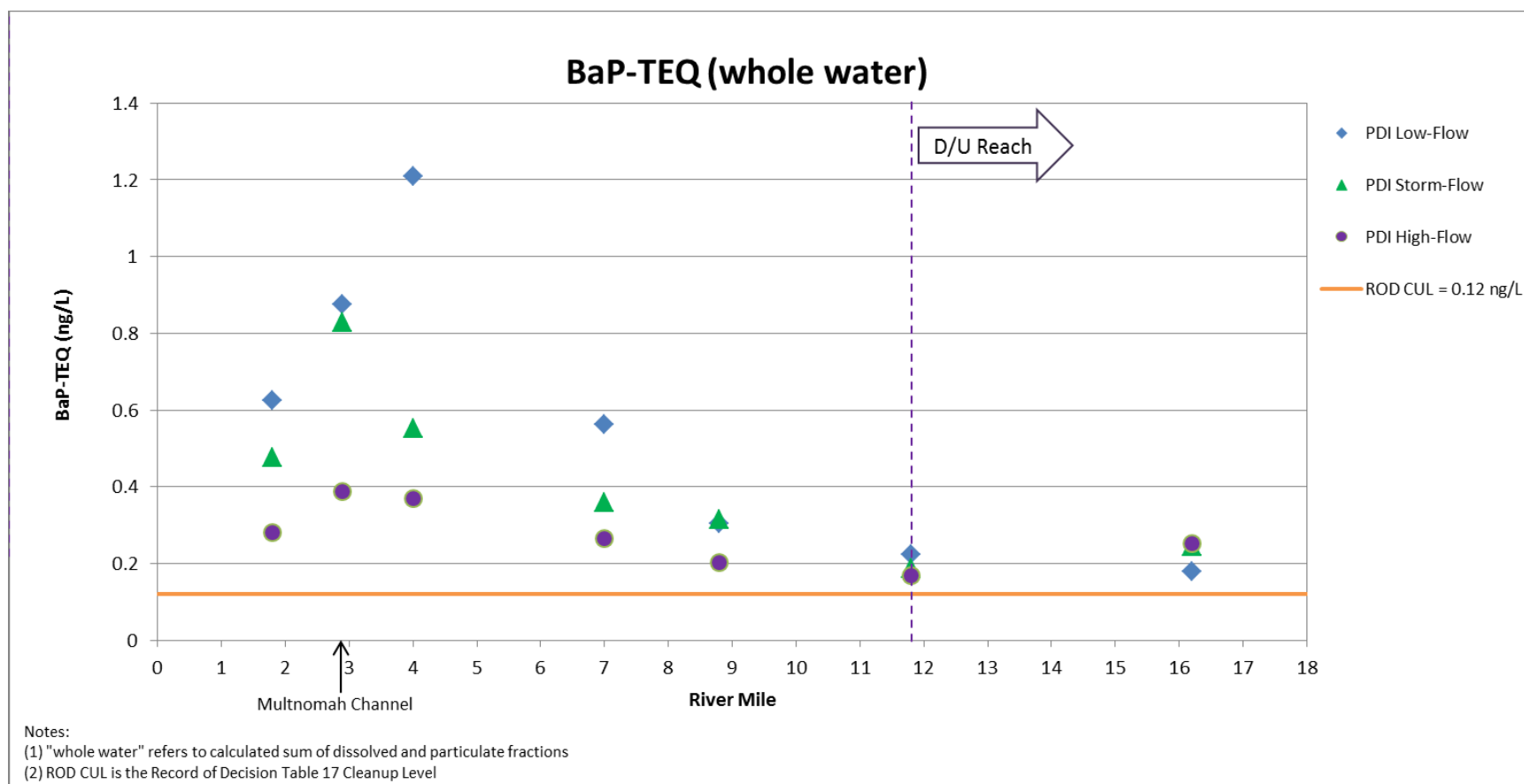
Figure 6. Concentrations of BaP-TEQ by River Mile
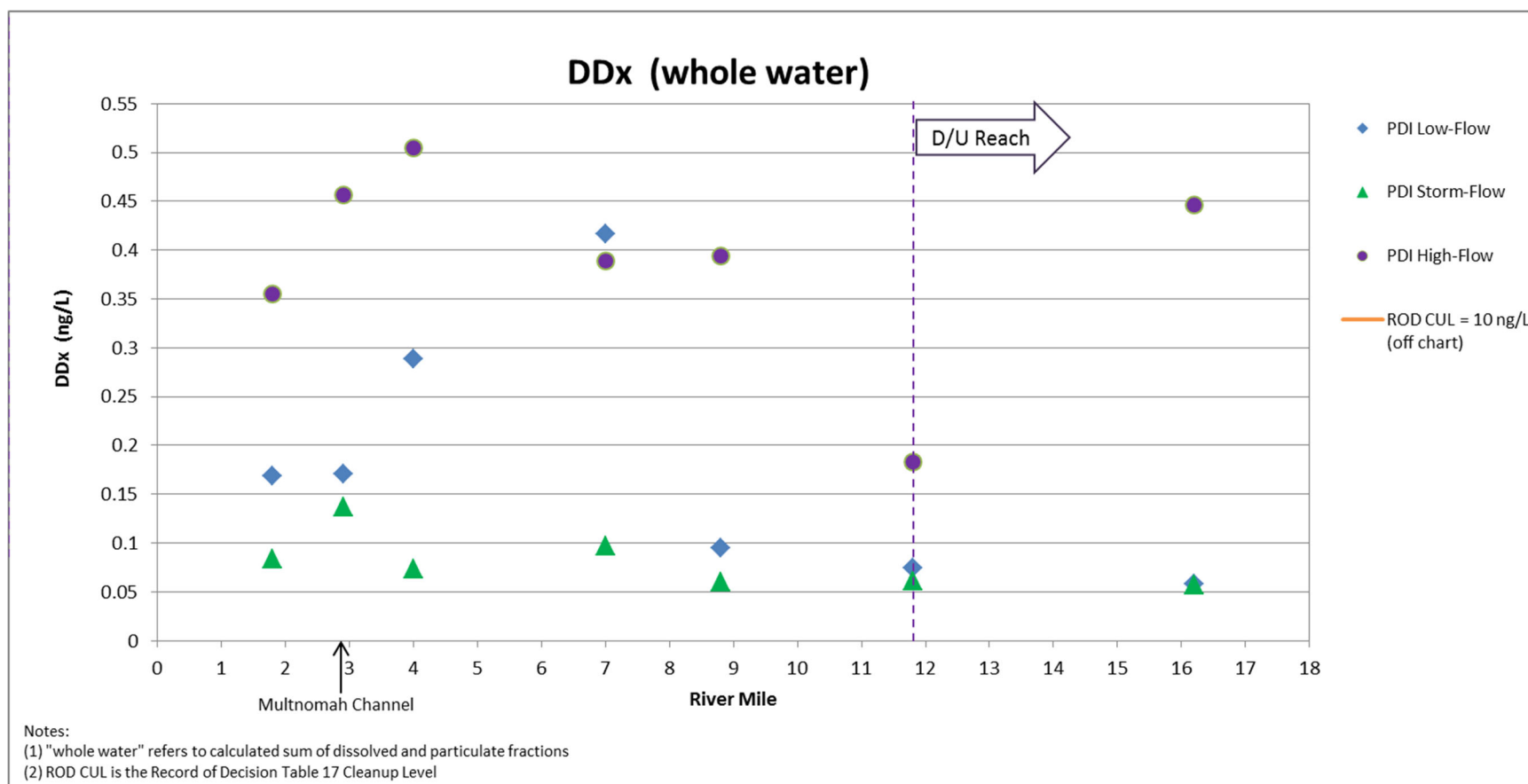
Figure 7. Concentrations of DDx by River Mile
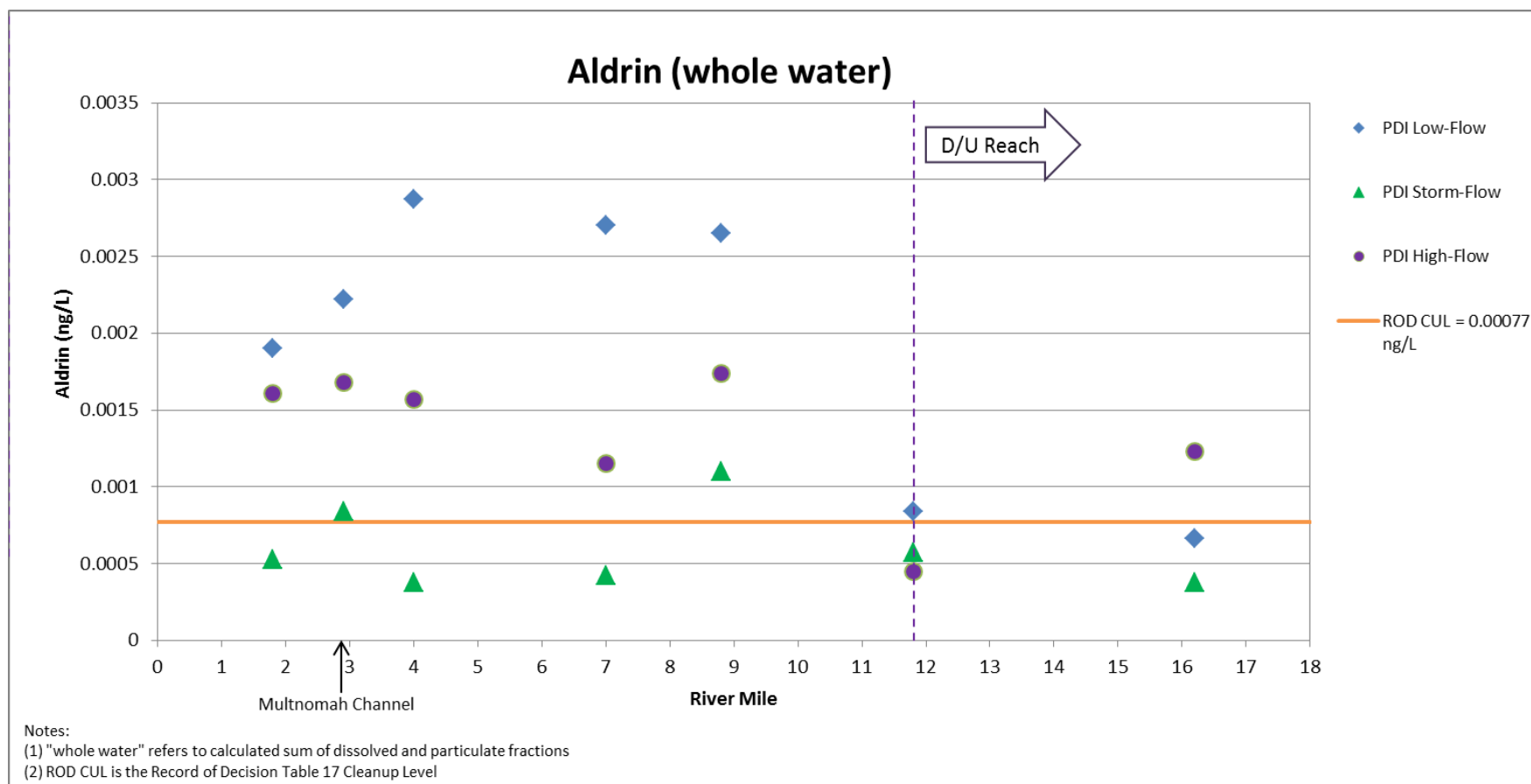
Figure 8. Concentrations of Aldrin by River Mile
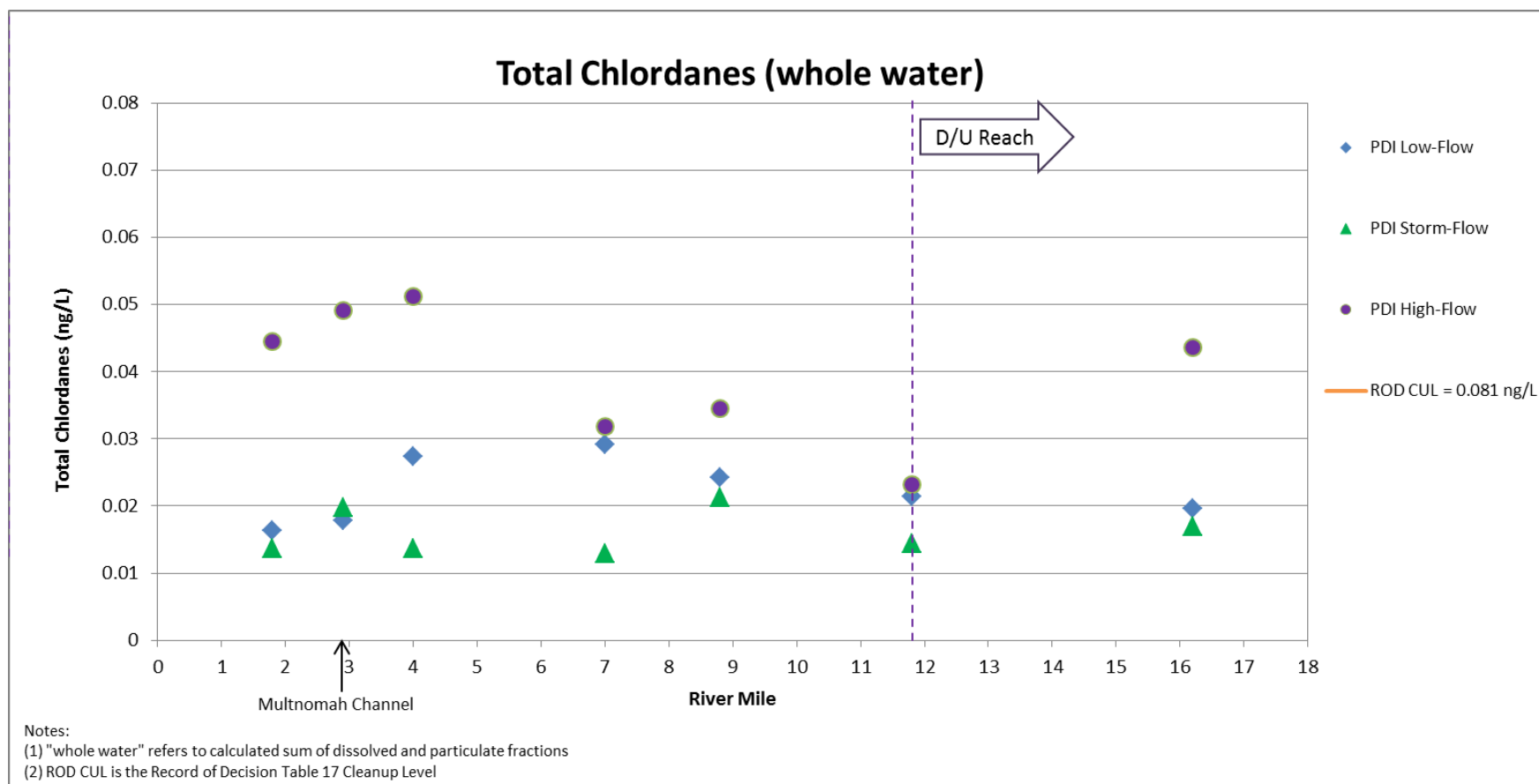
Figure 9. Concentrations of Total Chlordanes by River Mile
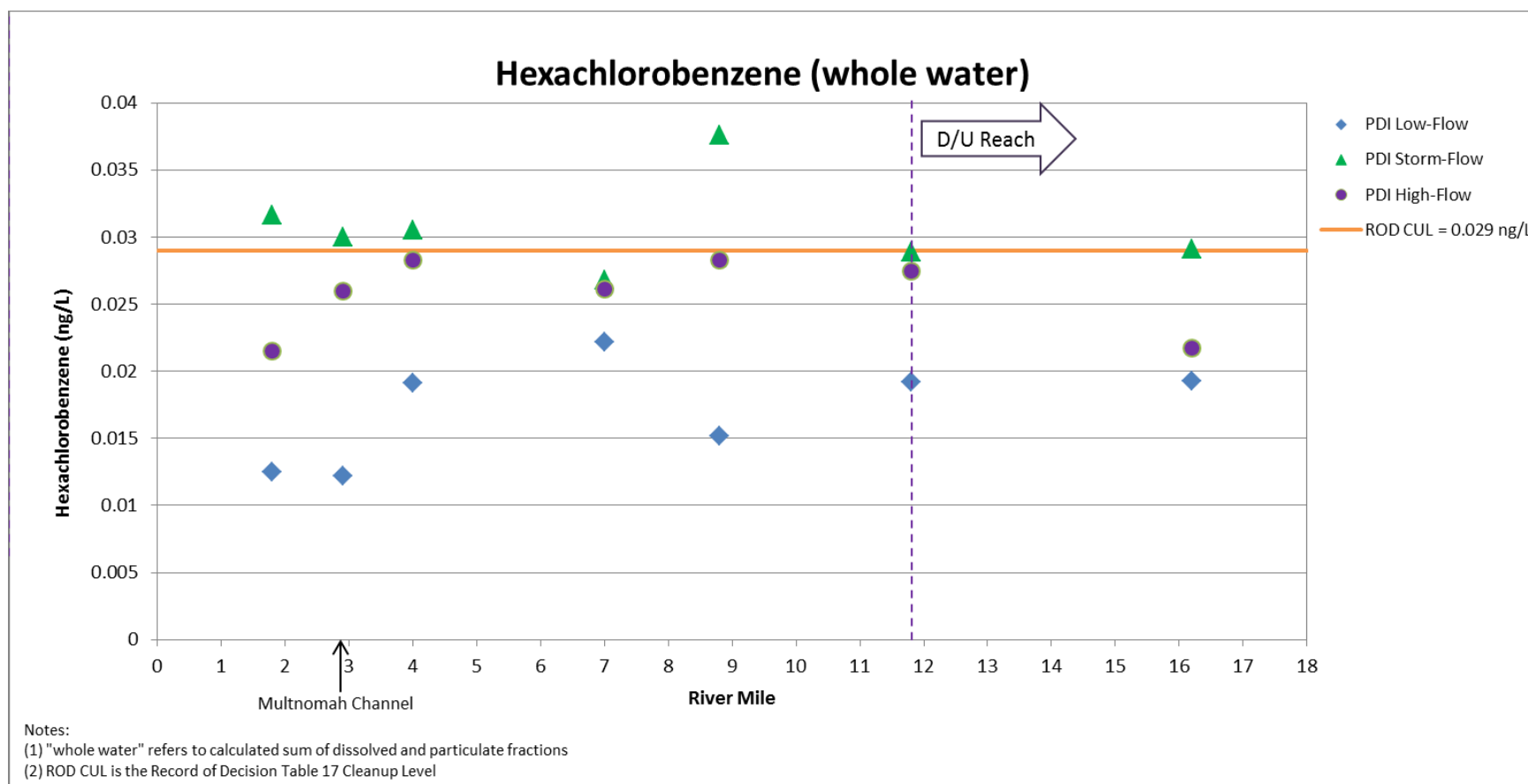
Figure 10. Concentrations of Hexachlorobenzene by River Mile
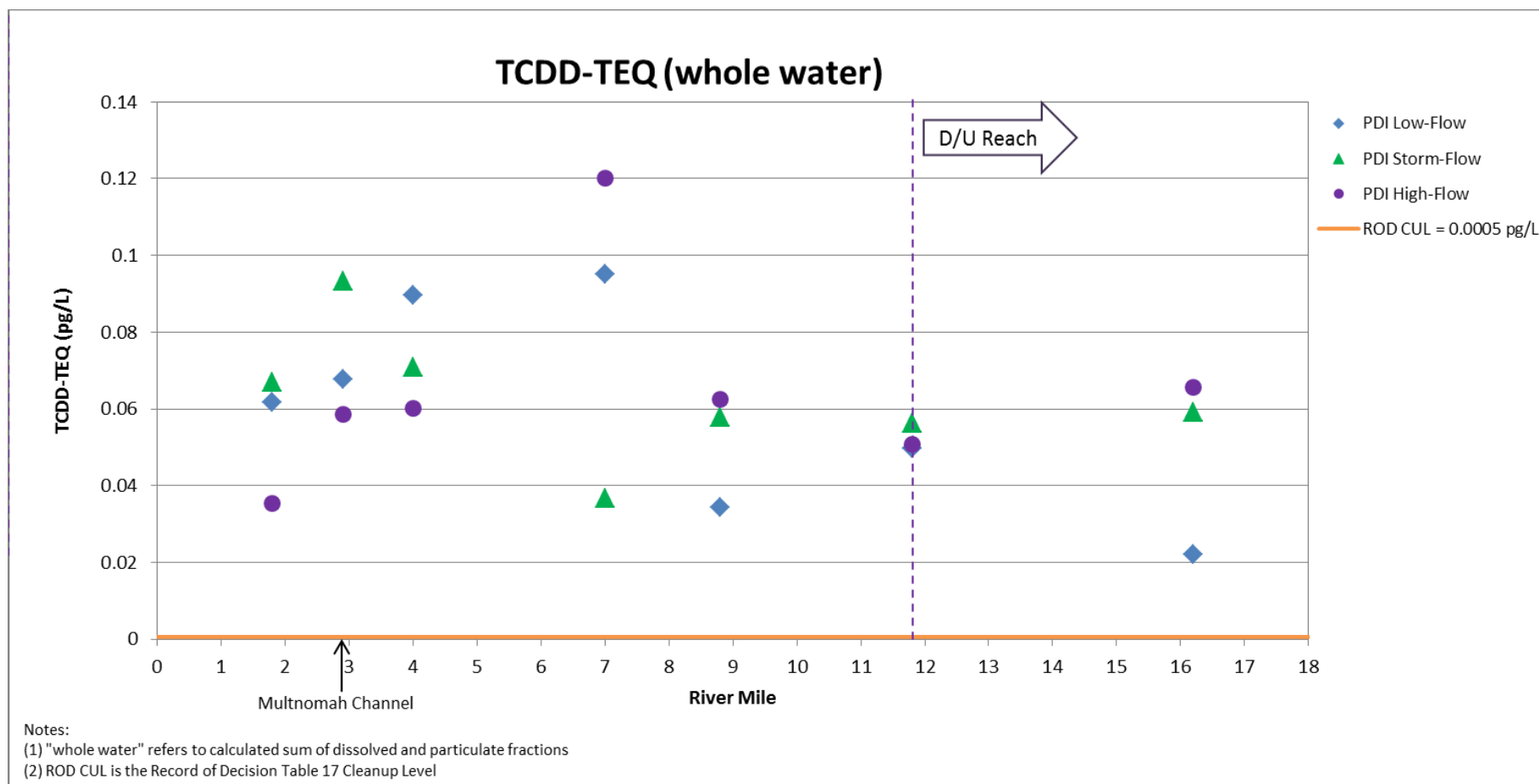
Figure 11. Concentrations of TCDD-TEQ by River Mile
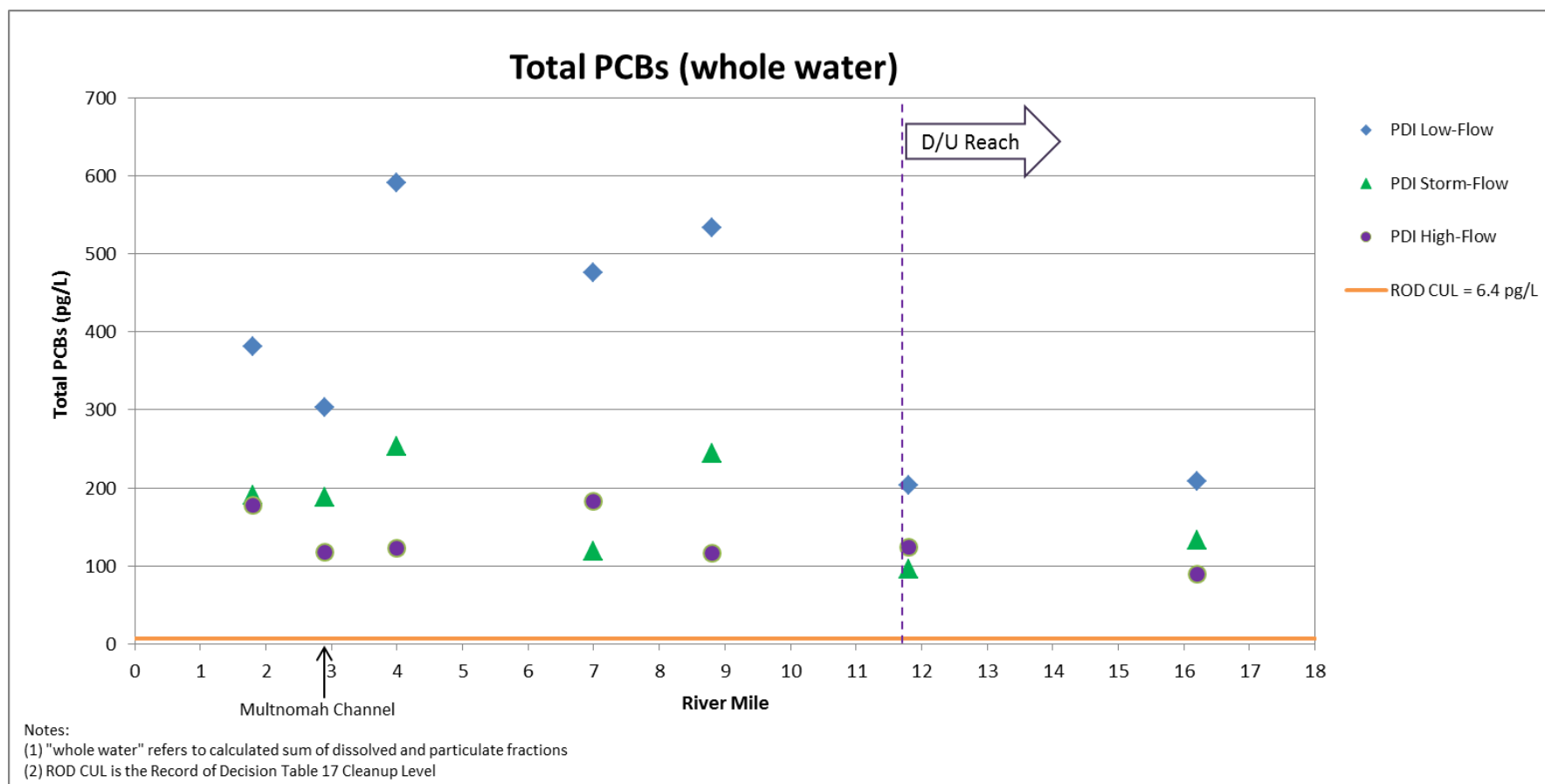
Figure 12. Concentrations of Total PCBs by River Mile
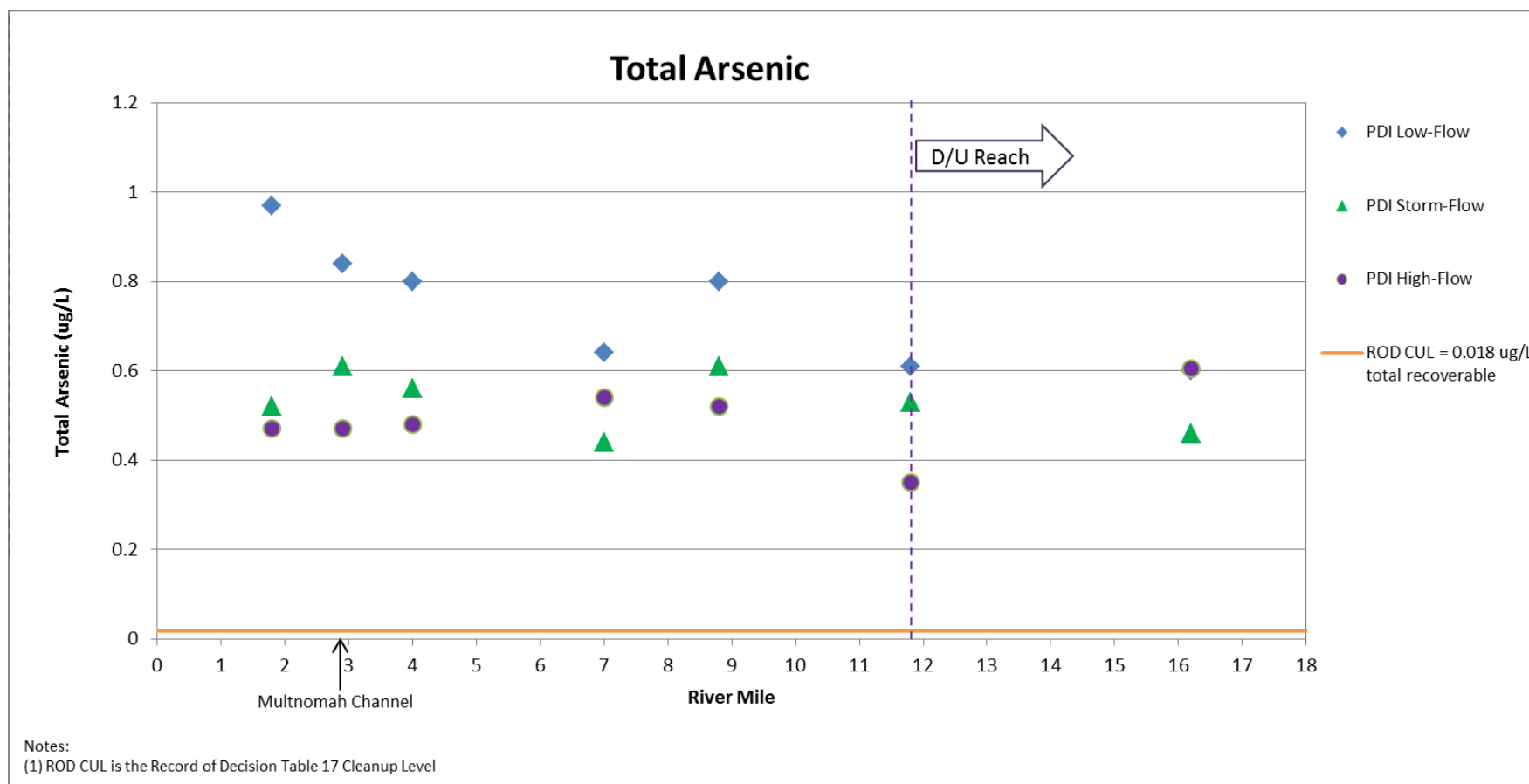
Figure 13. Concentrations of Total Arsenic by River Mile
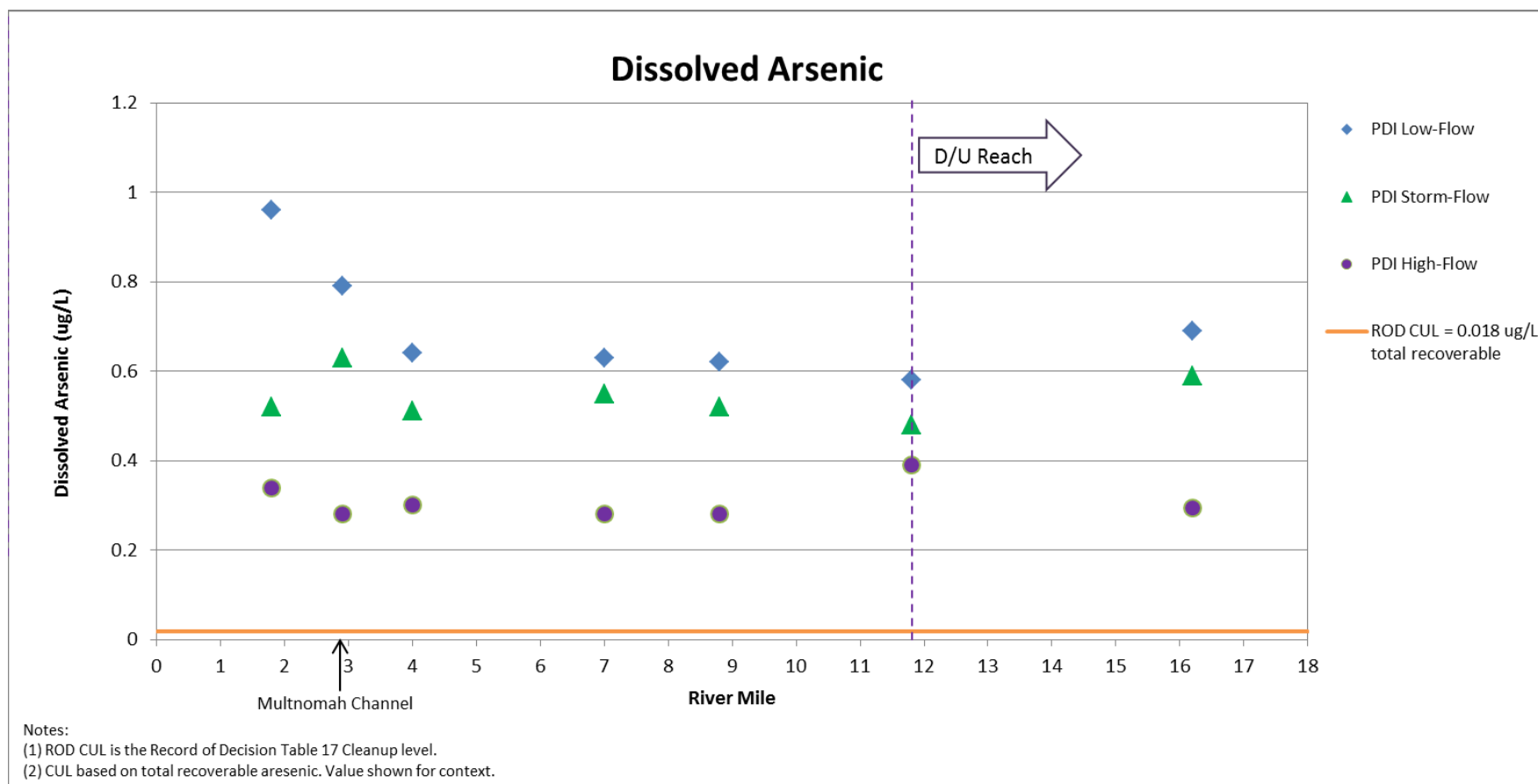
Figure 14. Concentrations of Dissolved Arsenic by River Mile
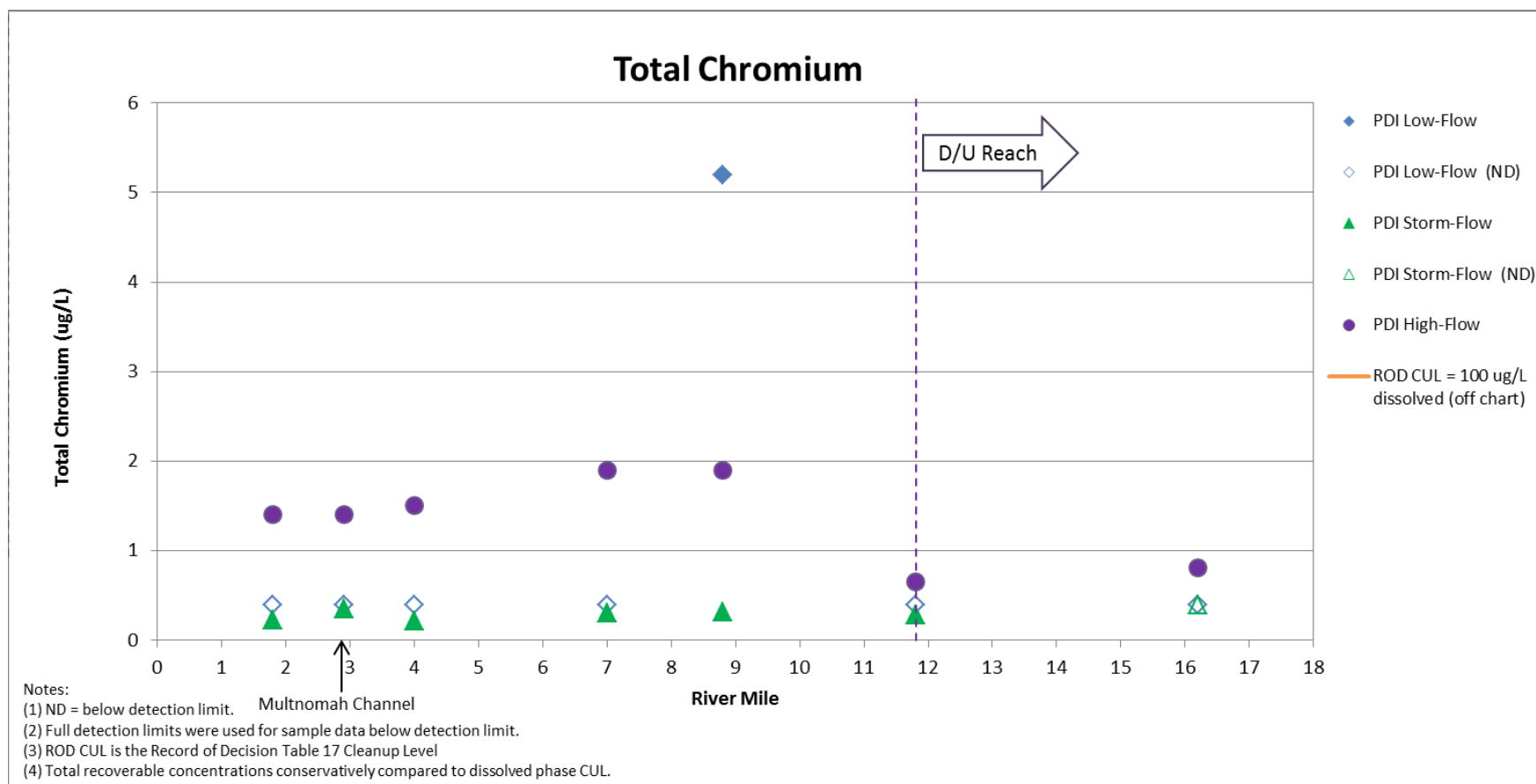
Figure 15. Concentrations of Total Chromium by River Mile
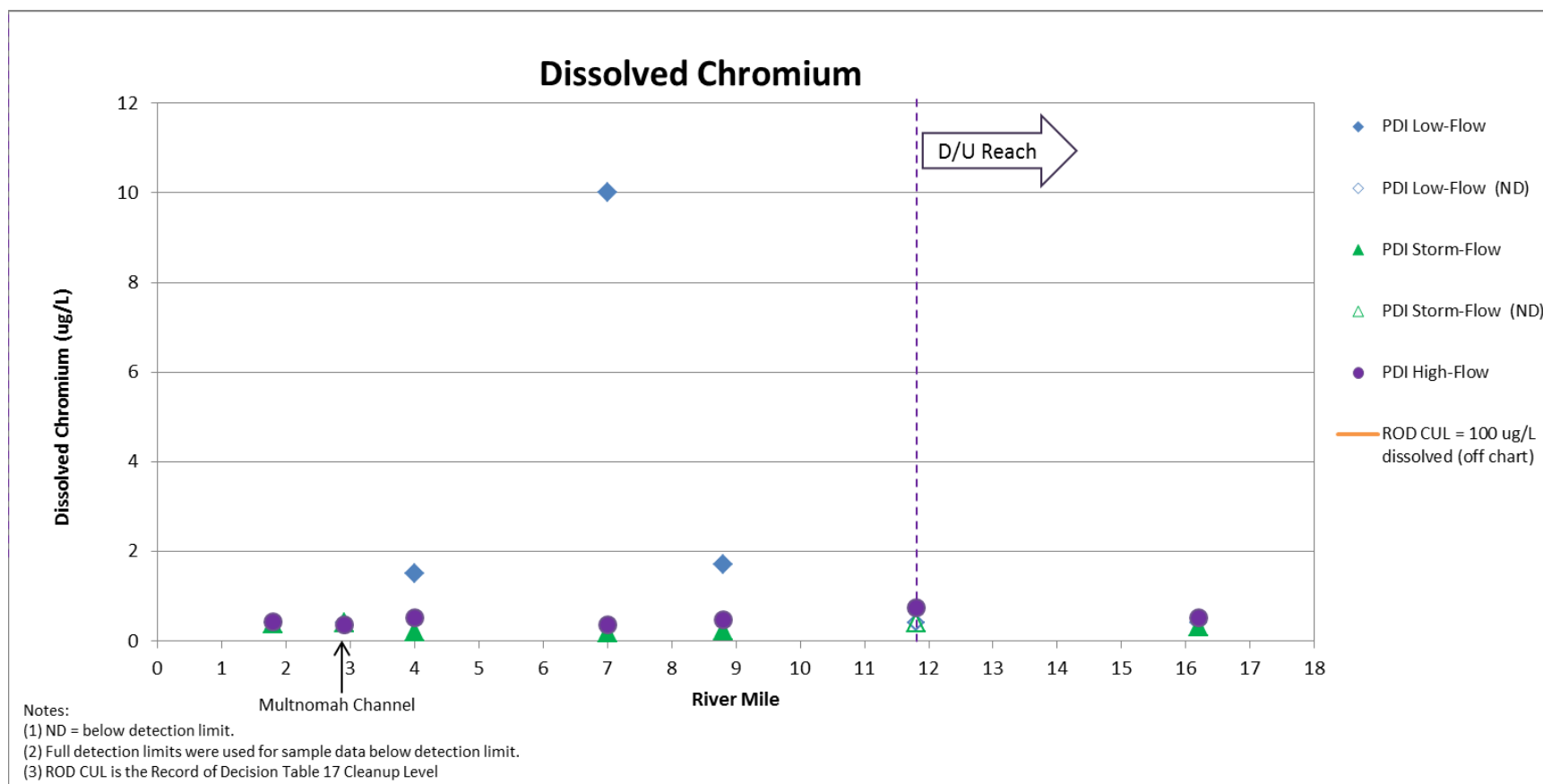
Figure 16. Concentrations of Dissolved Chromium by River Mile
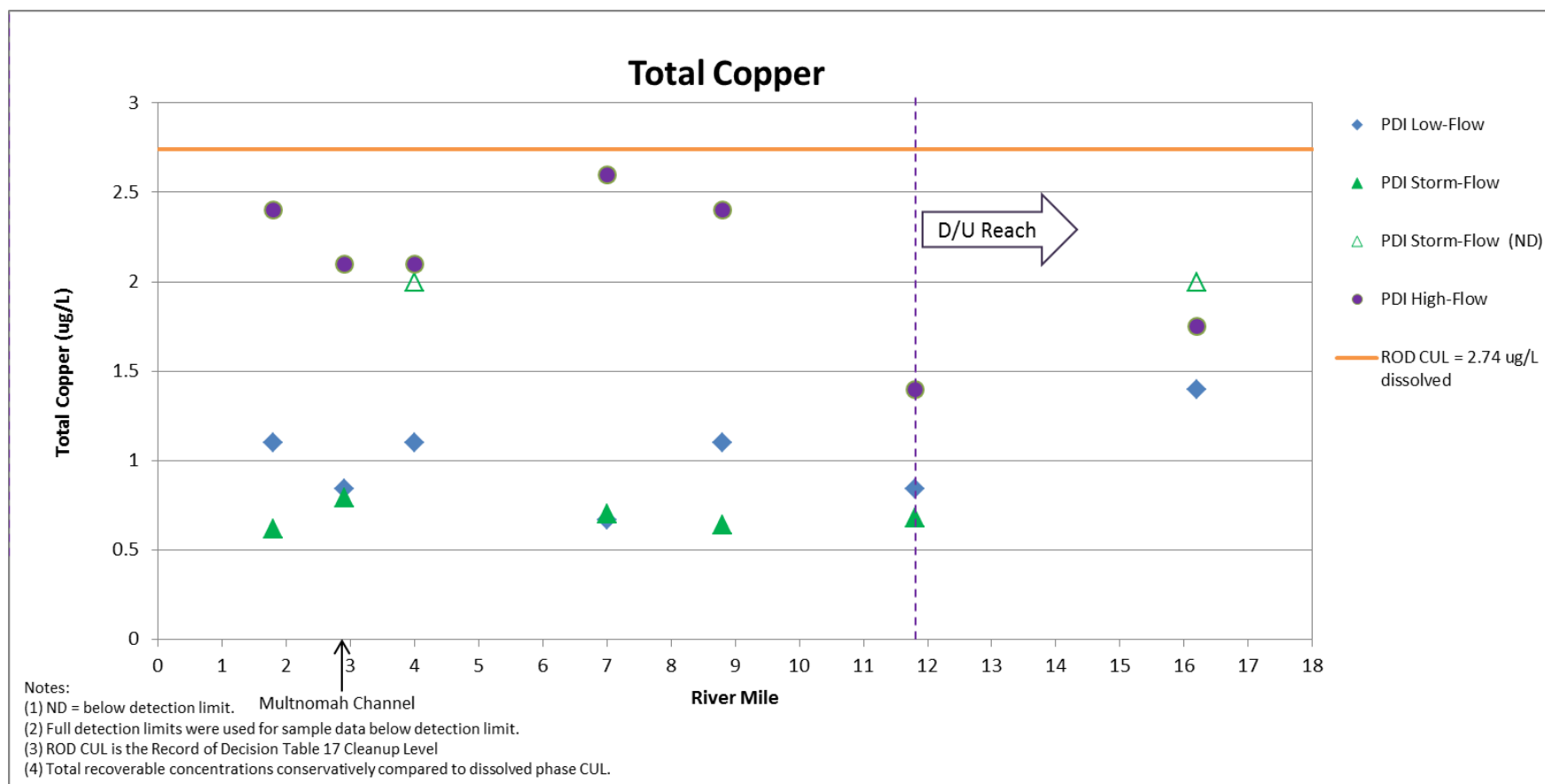
Figure 17. Concentrations of Total Copper by River Mile
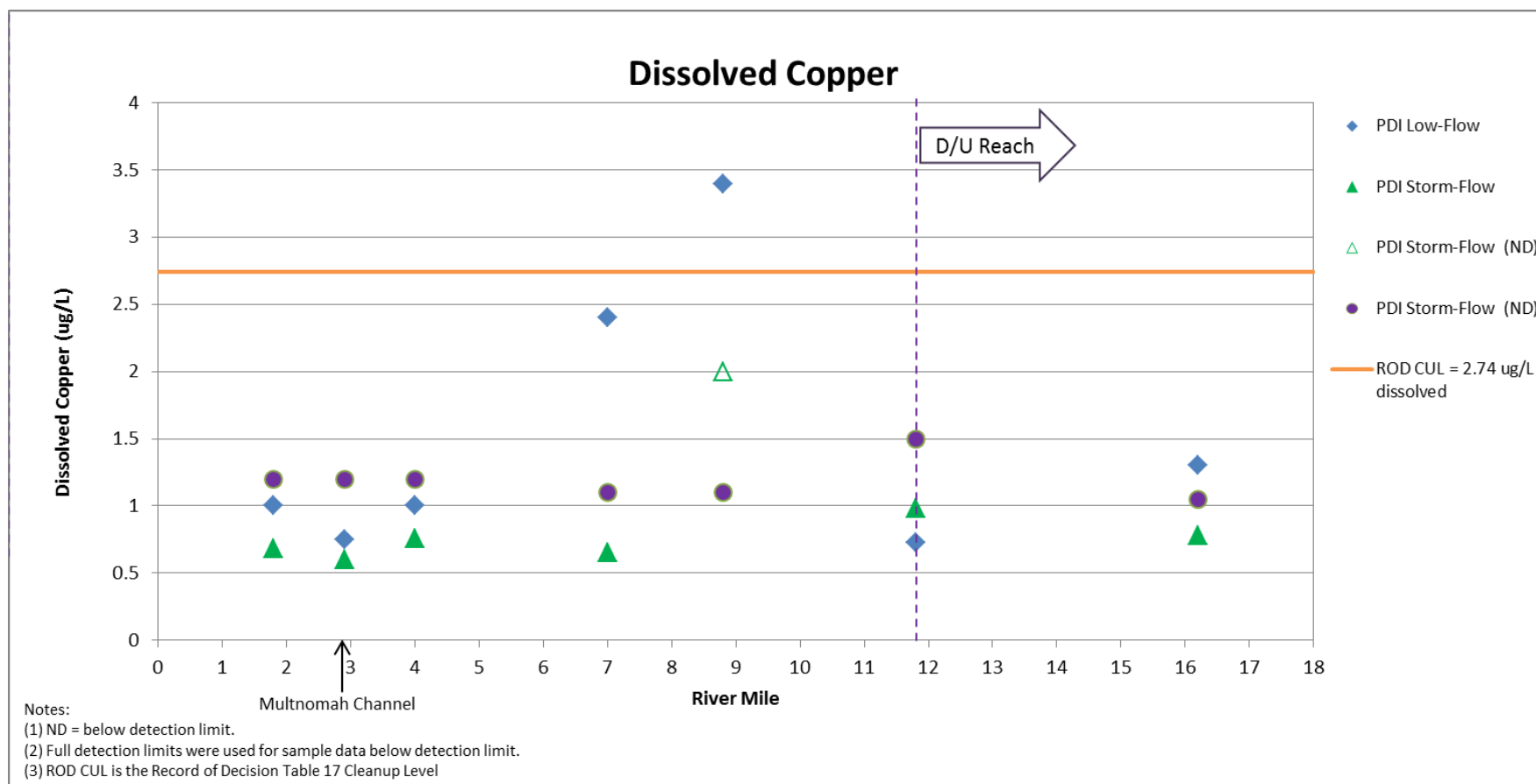
Figure 18. Concentrations of Dissolved Copper by River Mile
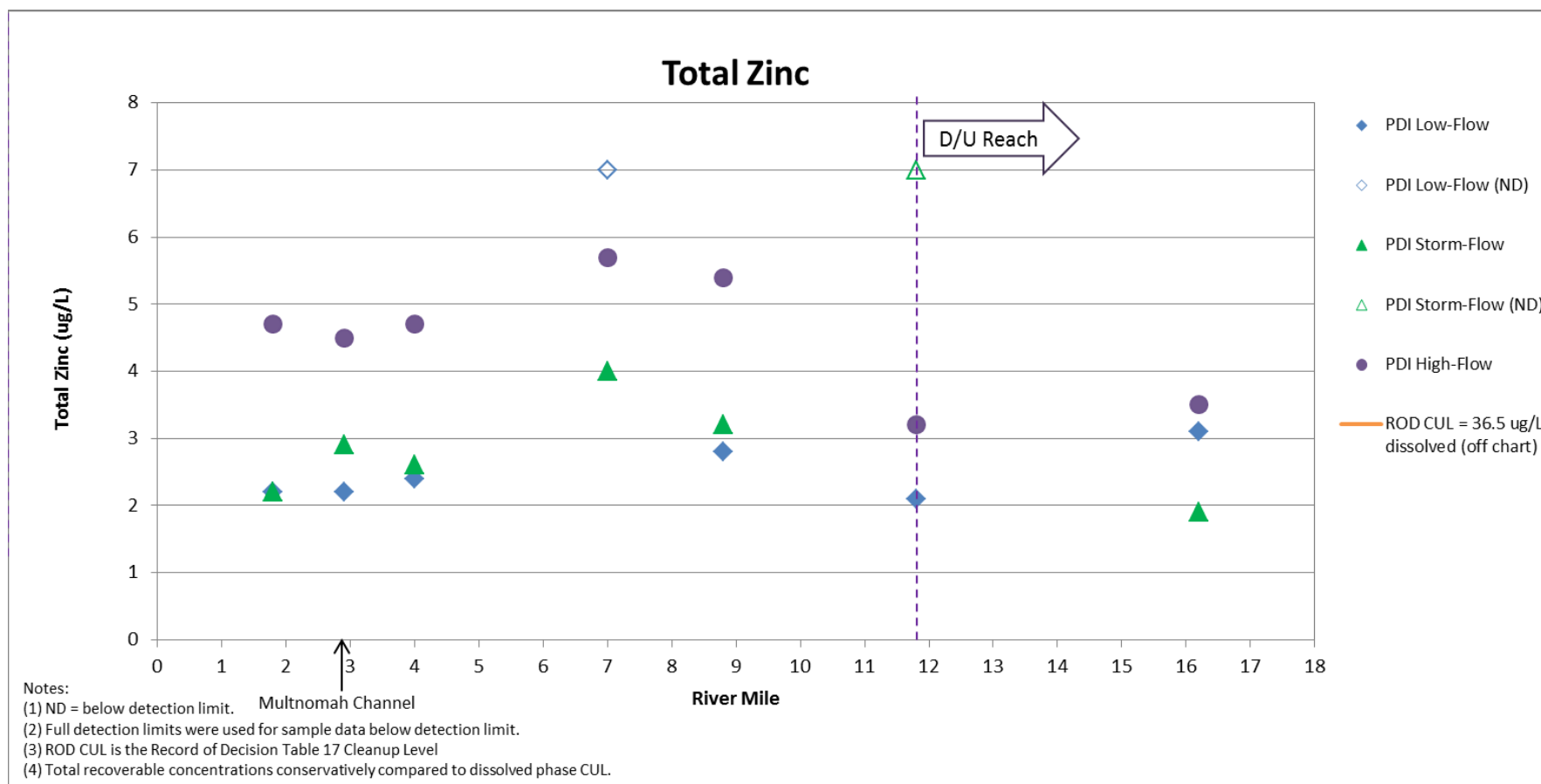
Figure 19. Concentrations of Total Zinc by River Mile
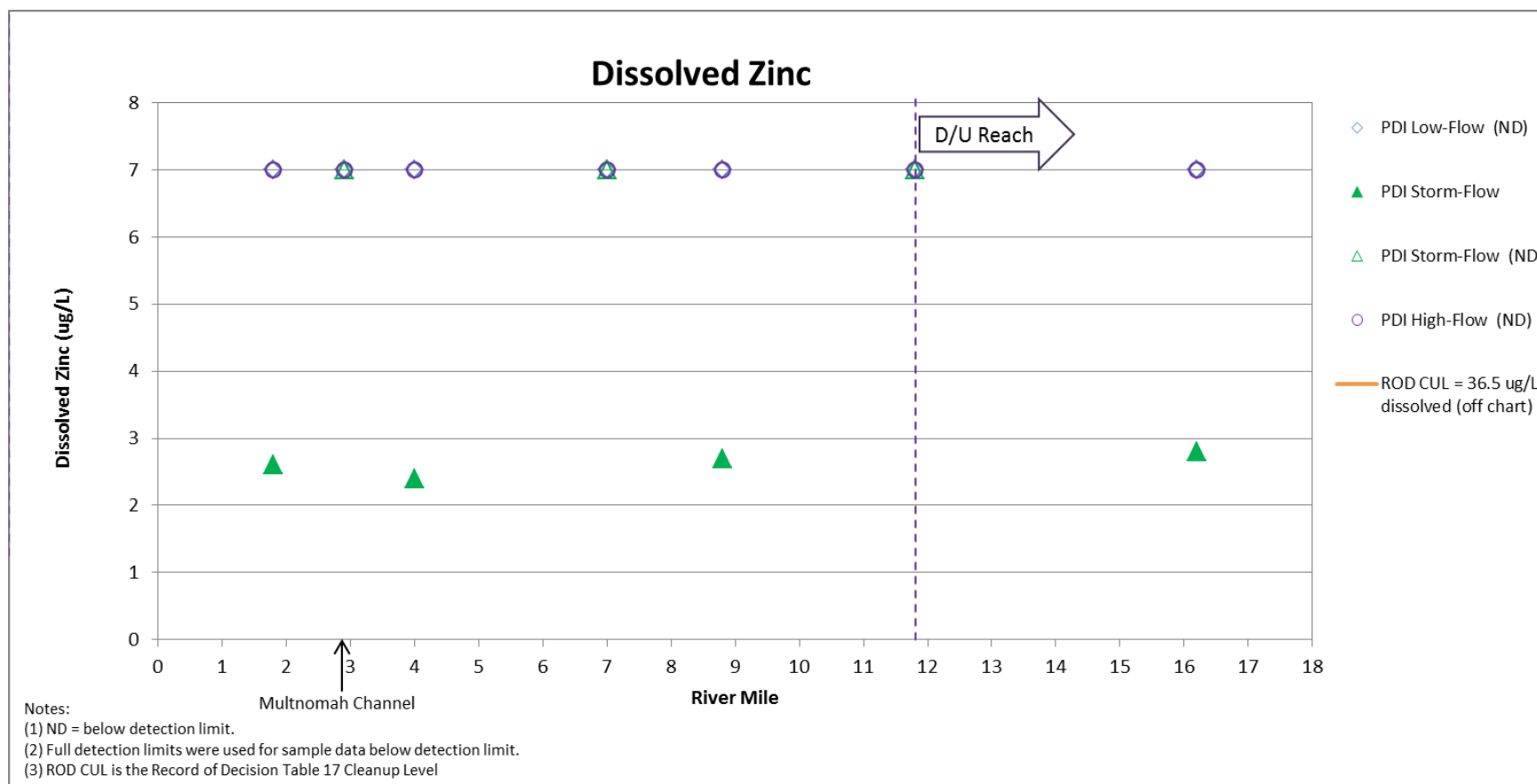
Figure 20. Concentrations of Dissolved Zinc by River Mile
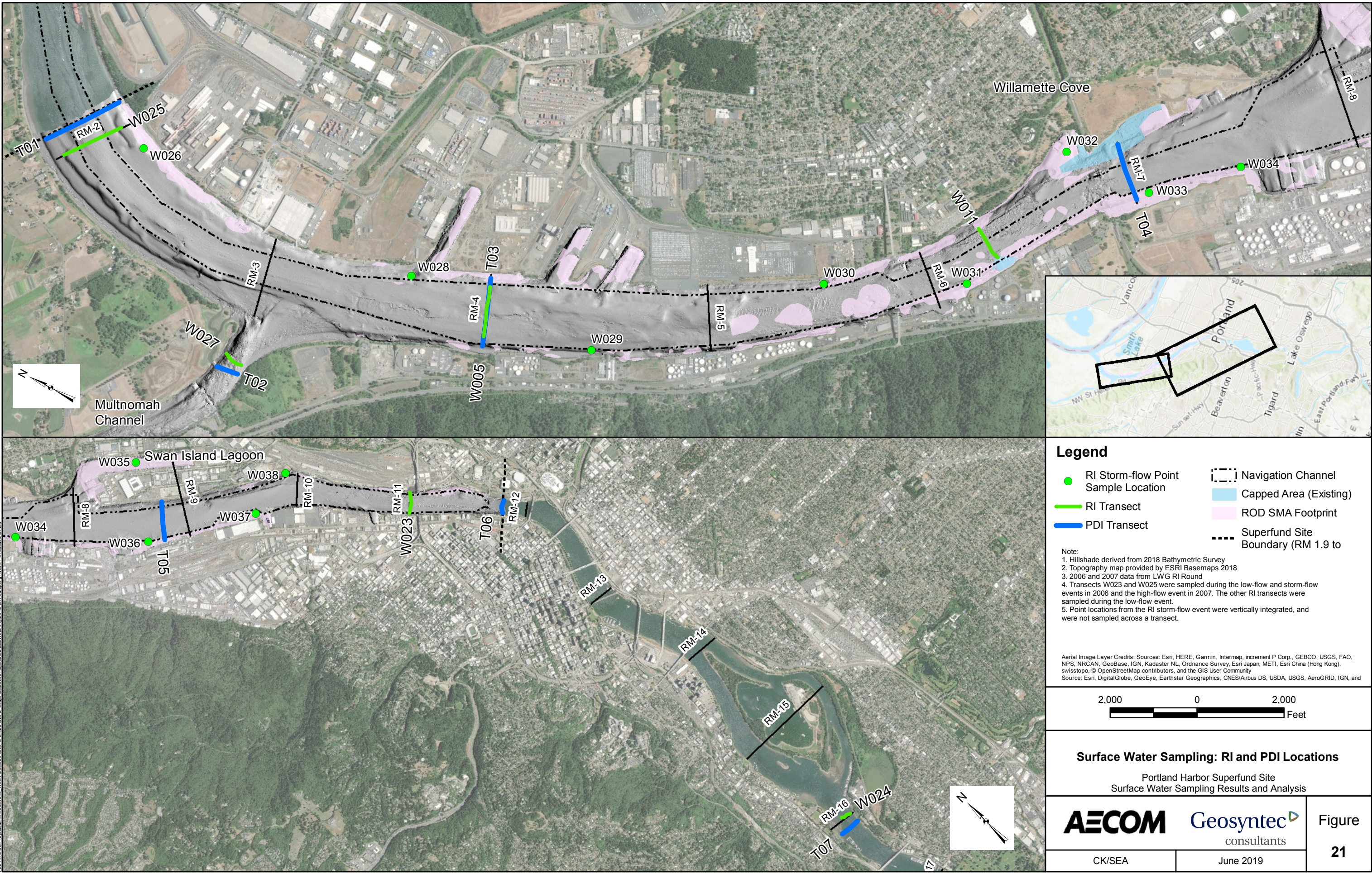
Legend

- ● RI Storm-flow Point Sample Location
- ▬ RI Transect (green)
- ▬ PDI Transect (blue)
- ⬚ Navigation Channel
- ▦ Capped Area (Existing)
- ▦ ROD SMA Footprint
- ⸱⸱⸱ Superfund Site Boundary (RM 1.9 to

Note:
1. Hillshade derived from 2018 Bathymetric Survey
2. Topography map provided by ESRI Basemaps 2018
3. 2006 and 2007 data from LWG RI Round
4. Transects W023 and W025 were sampled during the low-flow and storm-flow events in 2006 and the high-flow event in 2007. The other RI transects were sampled during the low-flow event.
5. Point locations from the RI storm-flow event were vertically integrated, and were not sampled across a transect.

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and

2,000   0   2,000 Feet
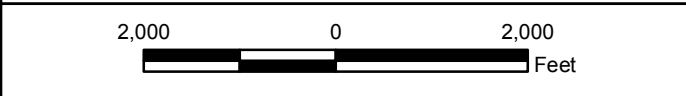
Surface Water Sampling: RI and PDI Locations

Portland Harbor Superfund Site
Surface Water Sampling Results and Analysis

AECOM   **Geosyntec** consultants

Figure
21

CK/SEA   June 2019
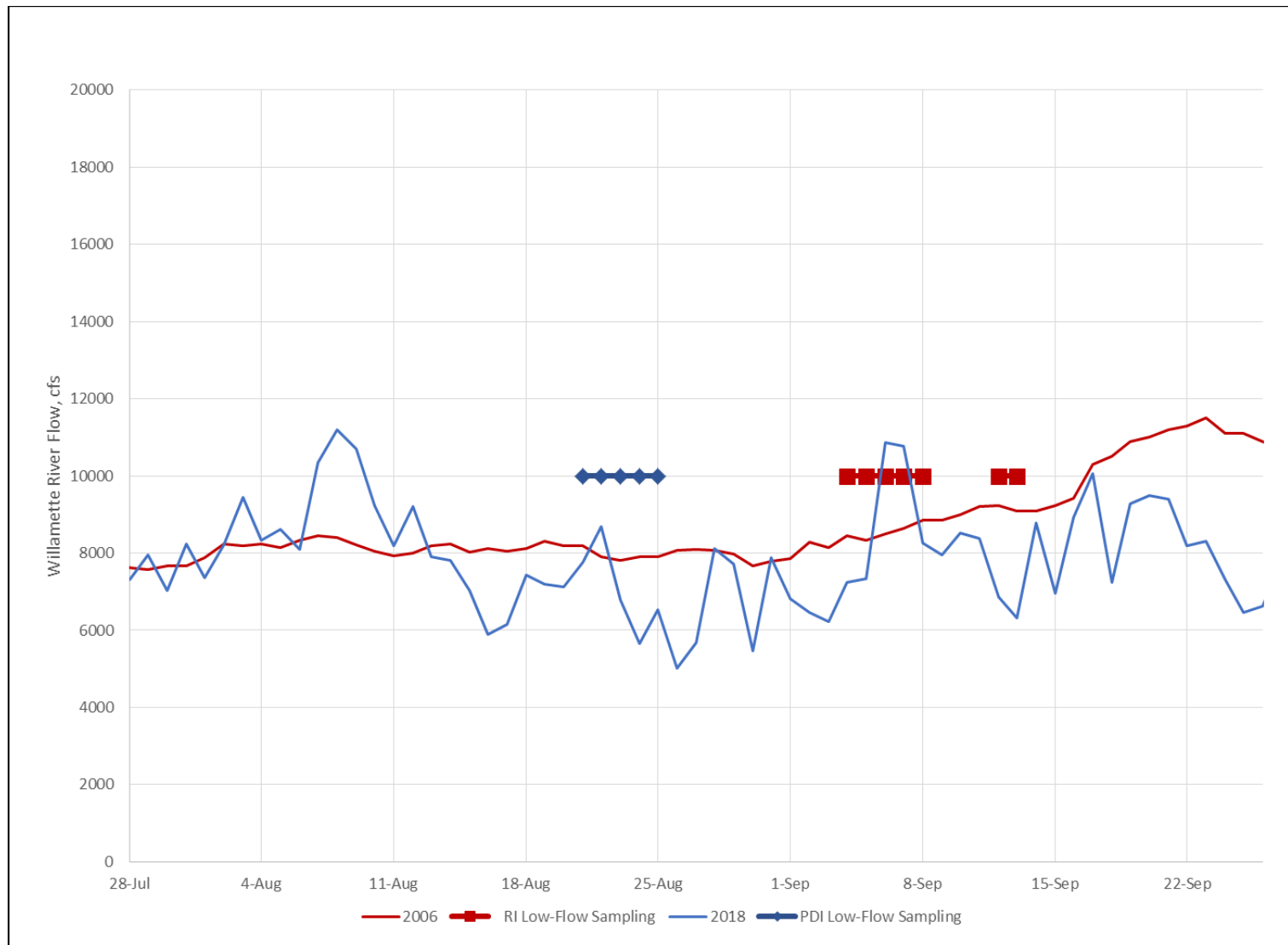
Figure 22. Discharge on the Willamette River in Portland (USGS Station 14211720) during the 2006 RI and 2018 PDI Low-Flow Sampling Events
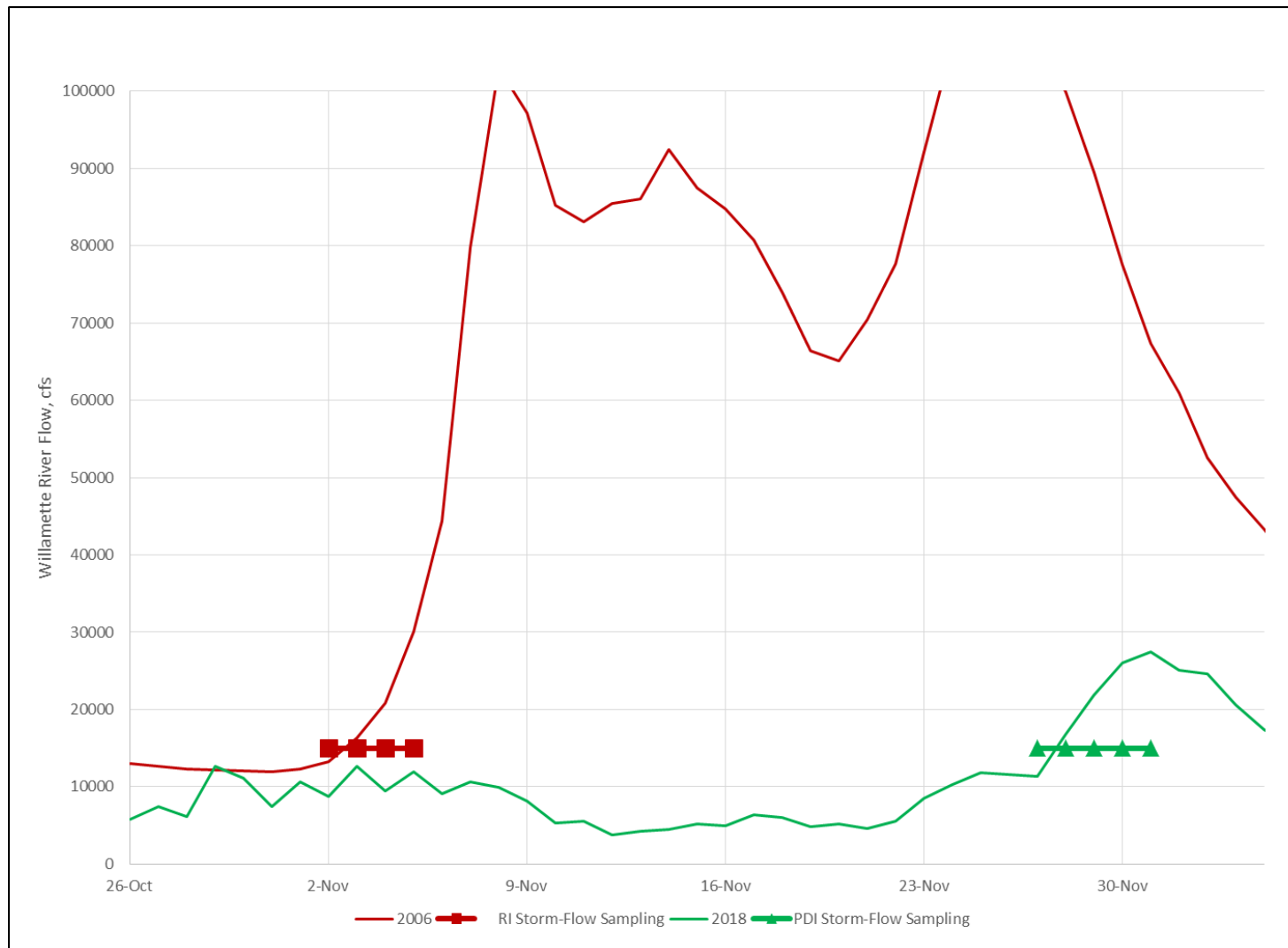
Figure 23. Discharge on the Willamette River in Portland (USGS Station 14211720) during the 2006 RI and 2018 PDI Storm-Flow Sampling Events
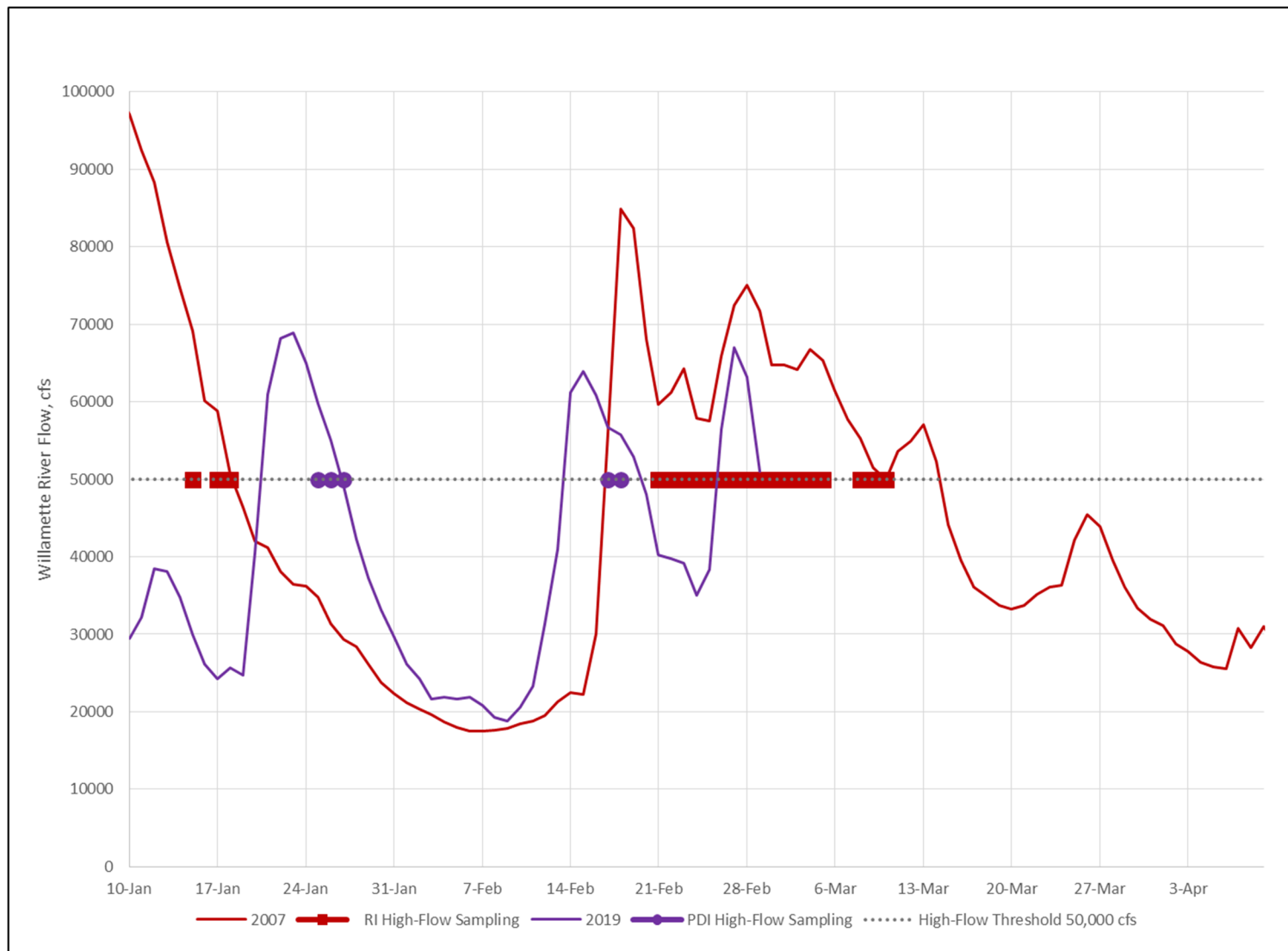
Figure 24. Discharge on the Willamette River in Portland (USGS Station 14211720) during the 2007 RI and 2019 PDI High-Flow Sampling Events
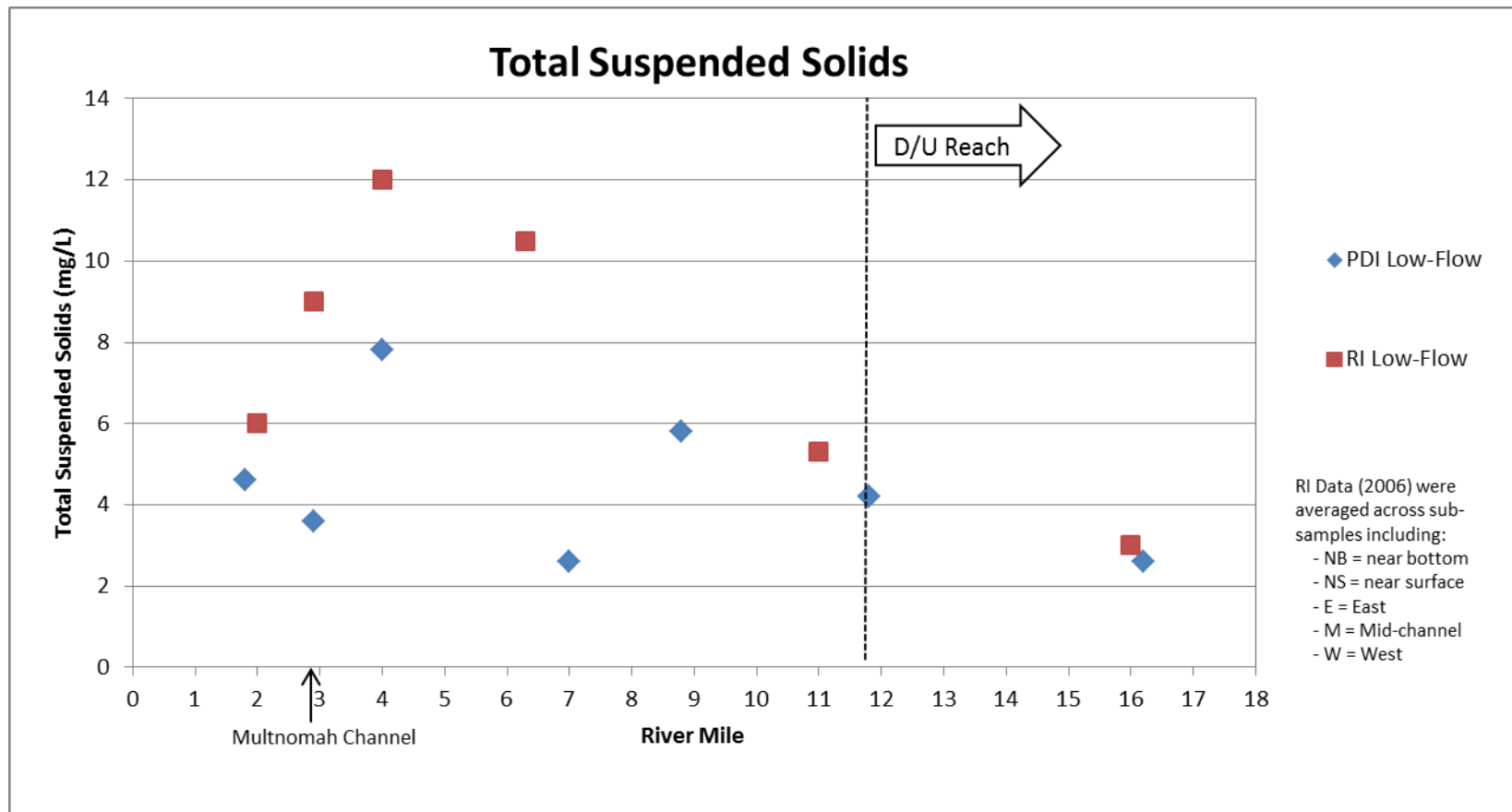
Figure 25. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI). Total Suspended Solids
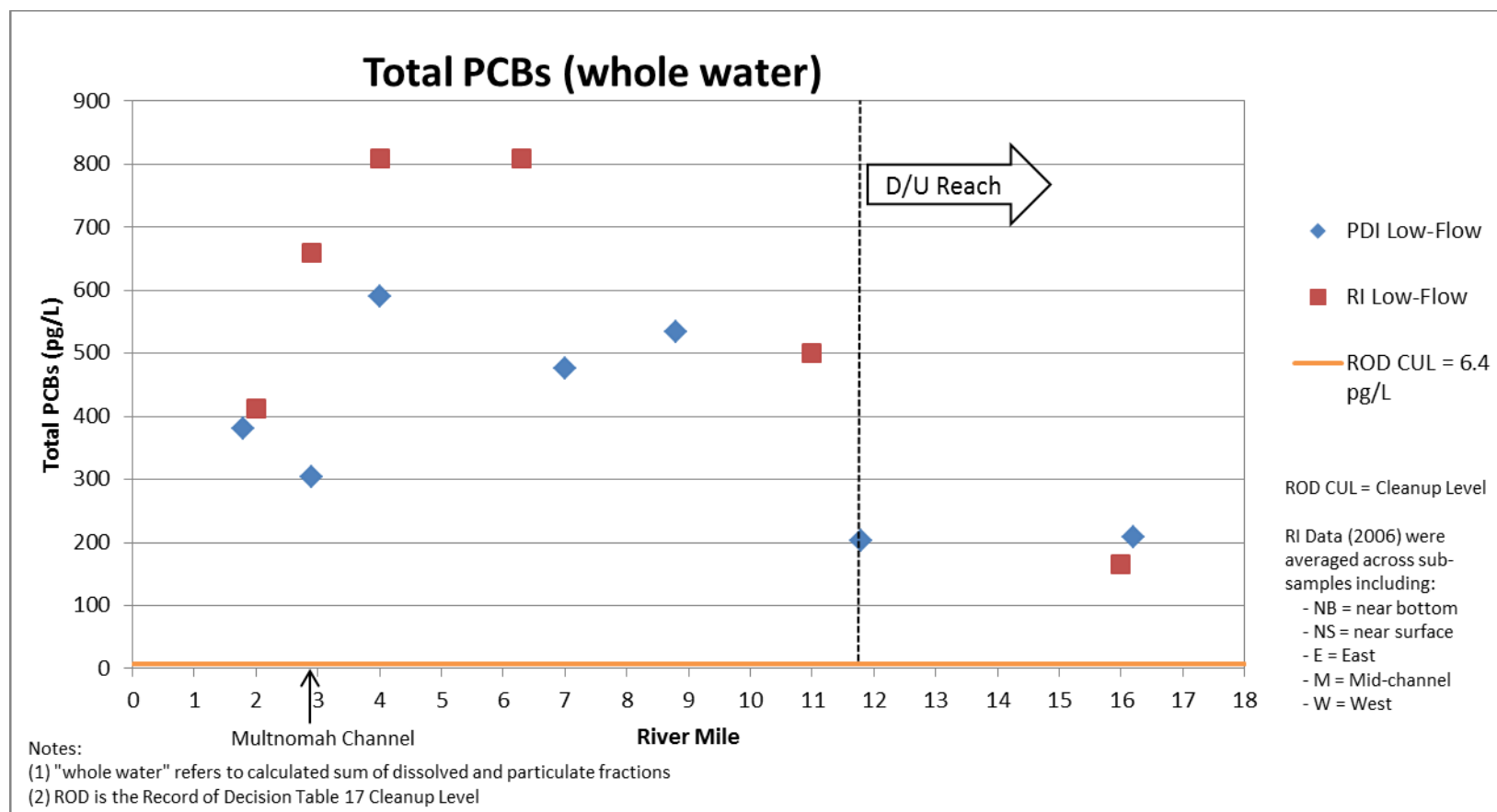
Figure 26. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI). Total PCBs in Whole Water
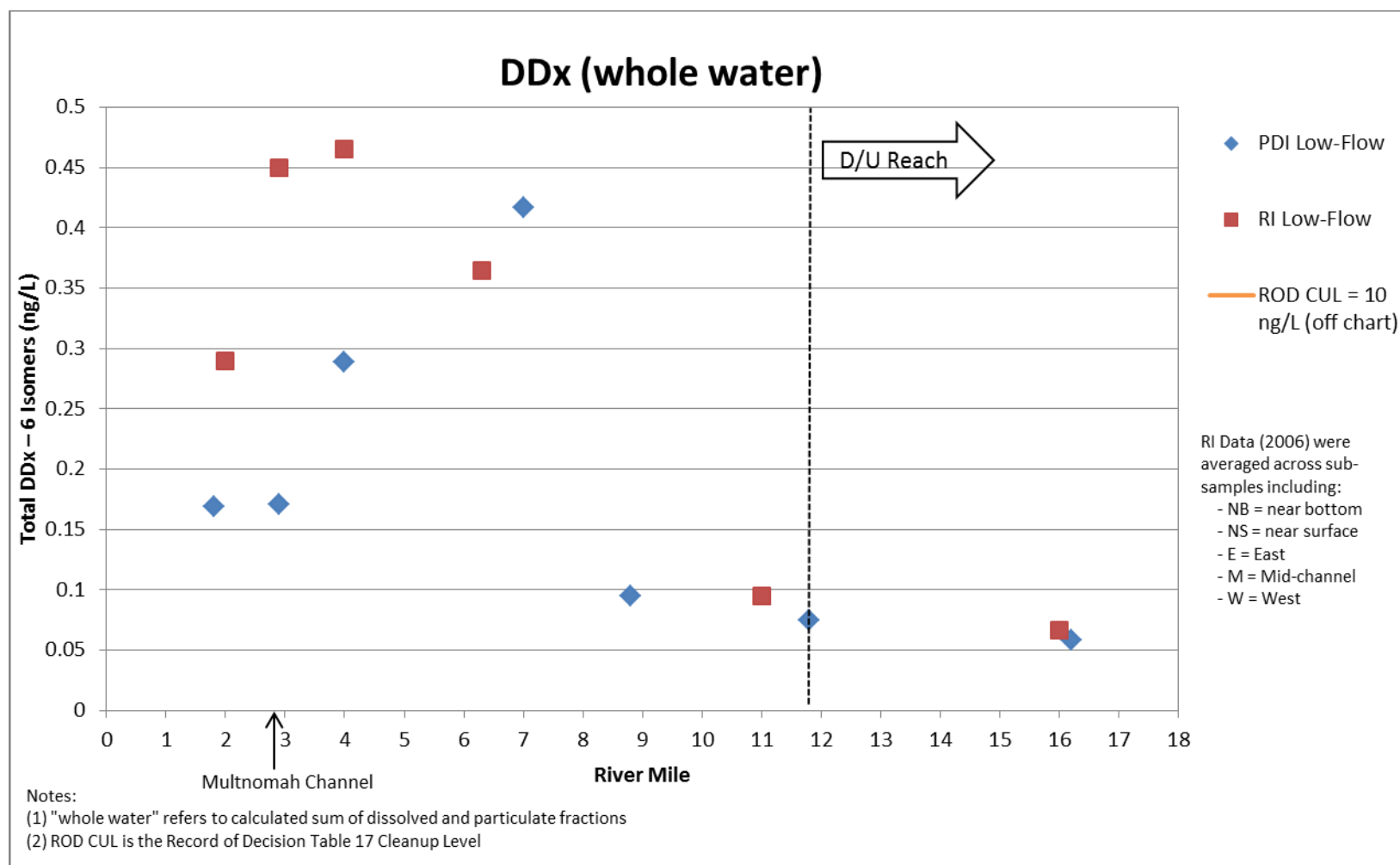
Figure 27. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI). DDx in Whole Water
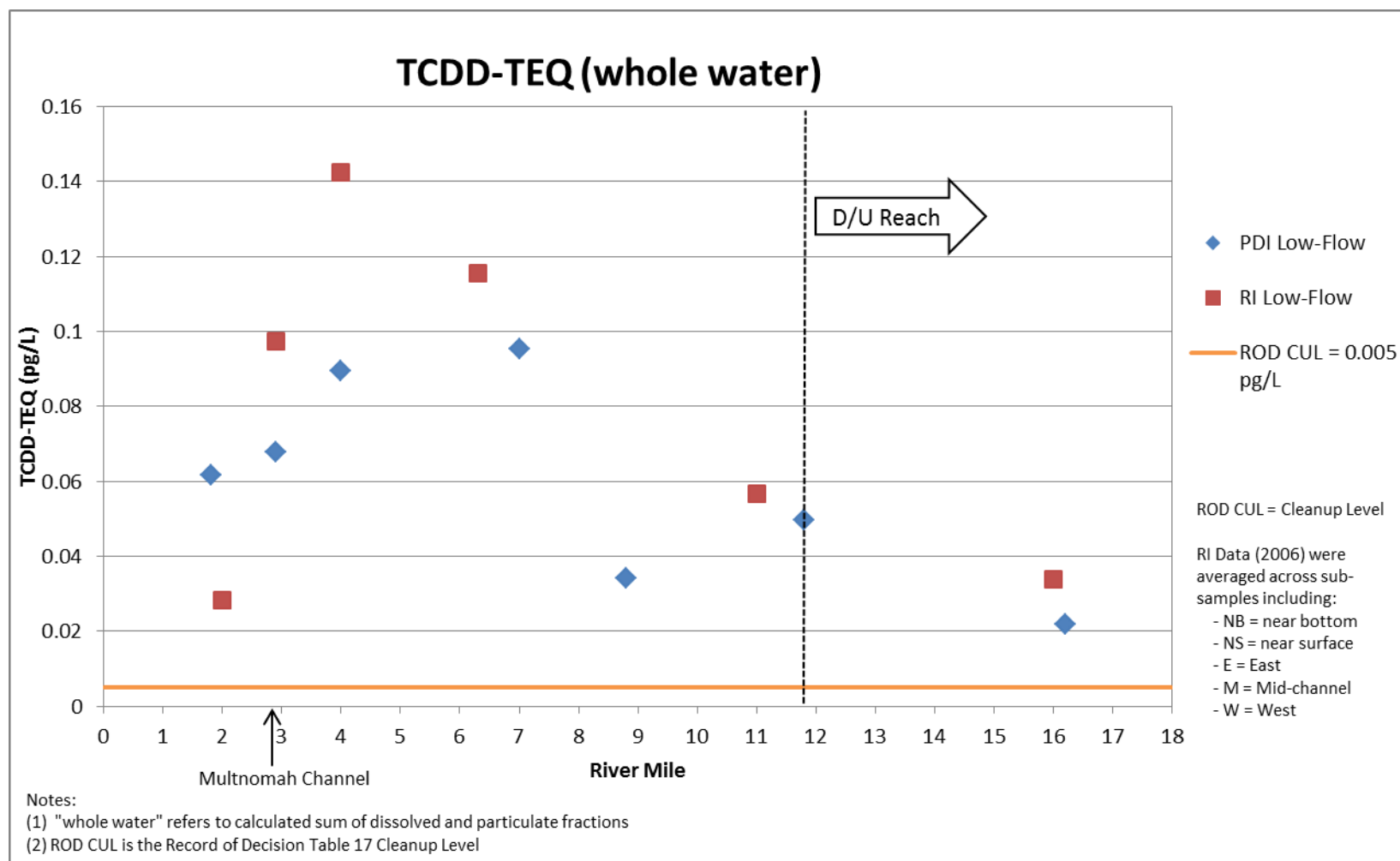
Figure 28. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI). TCDD-TEQ in Whole Water
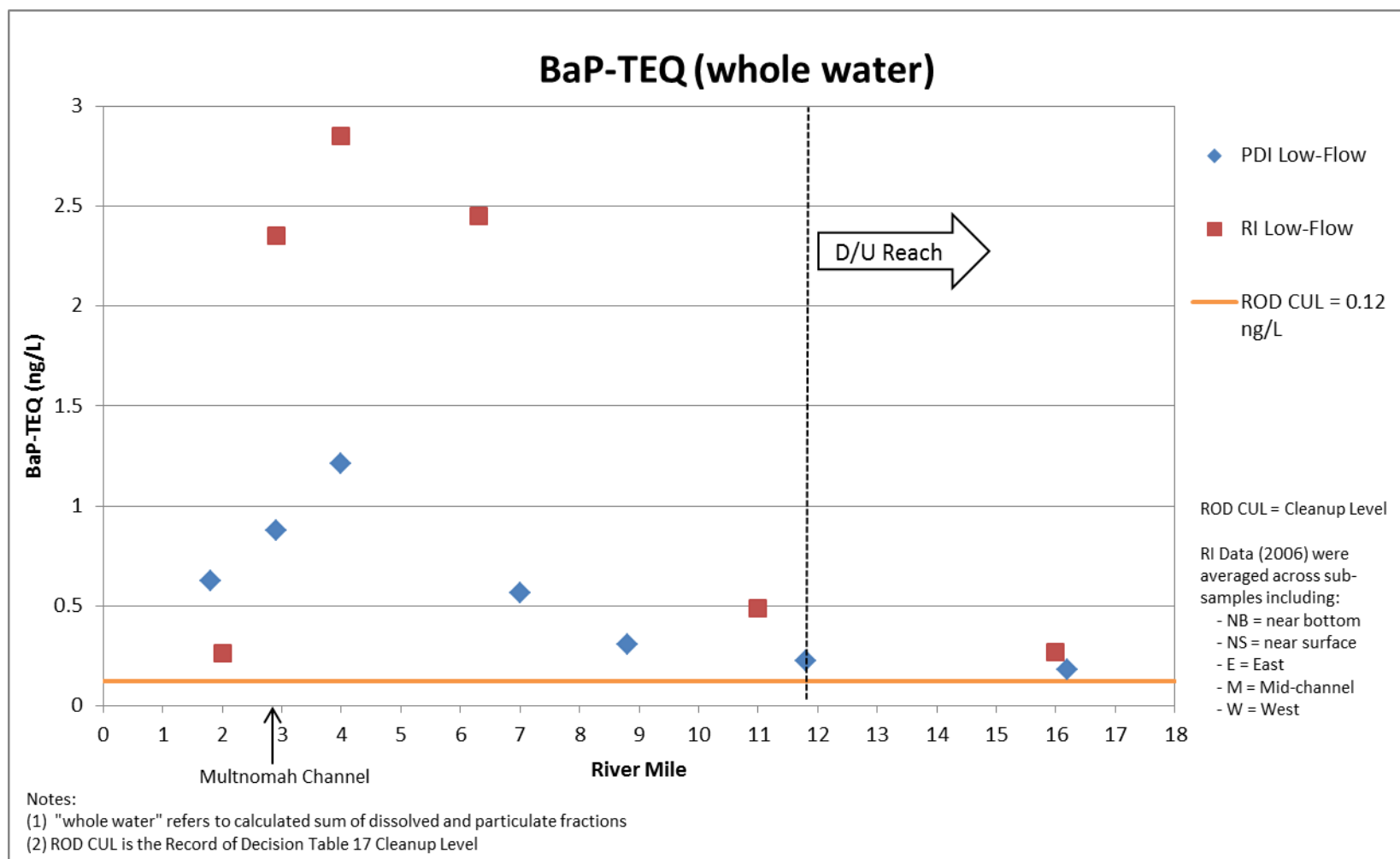
Figure 29. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI). BaP-TEQ in Whole Water
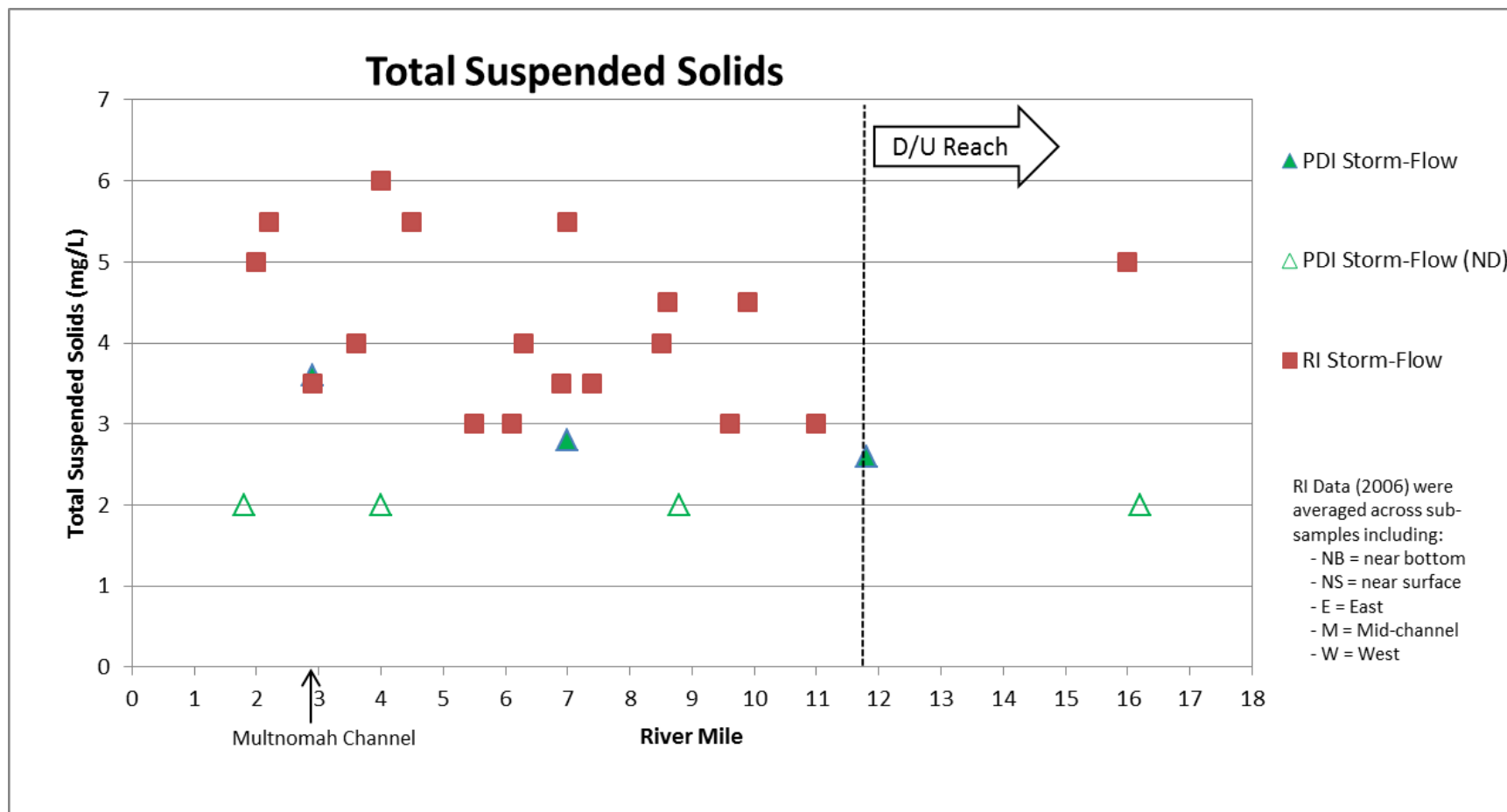
Figure 30. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI). Total Suspended Solids
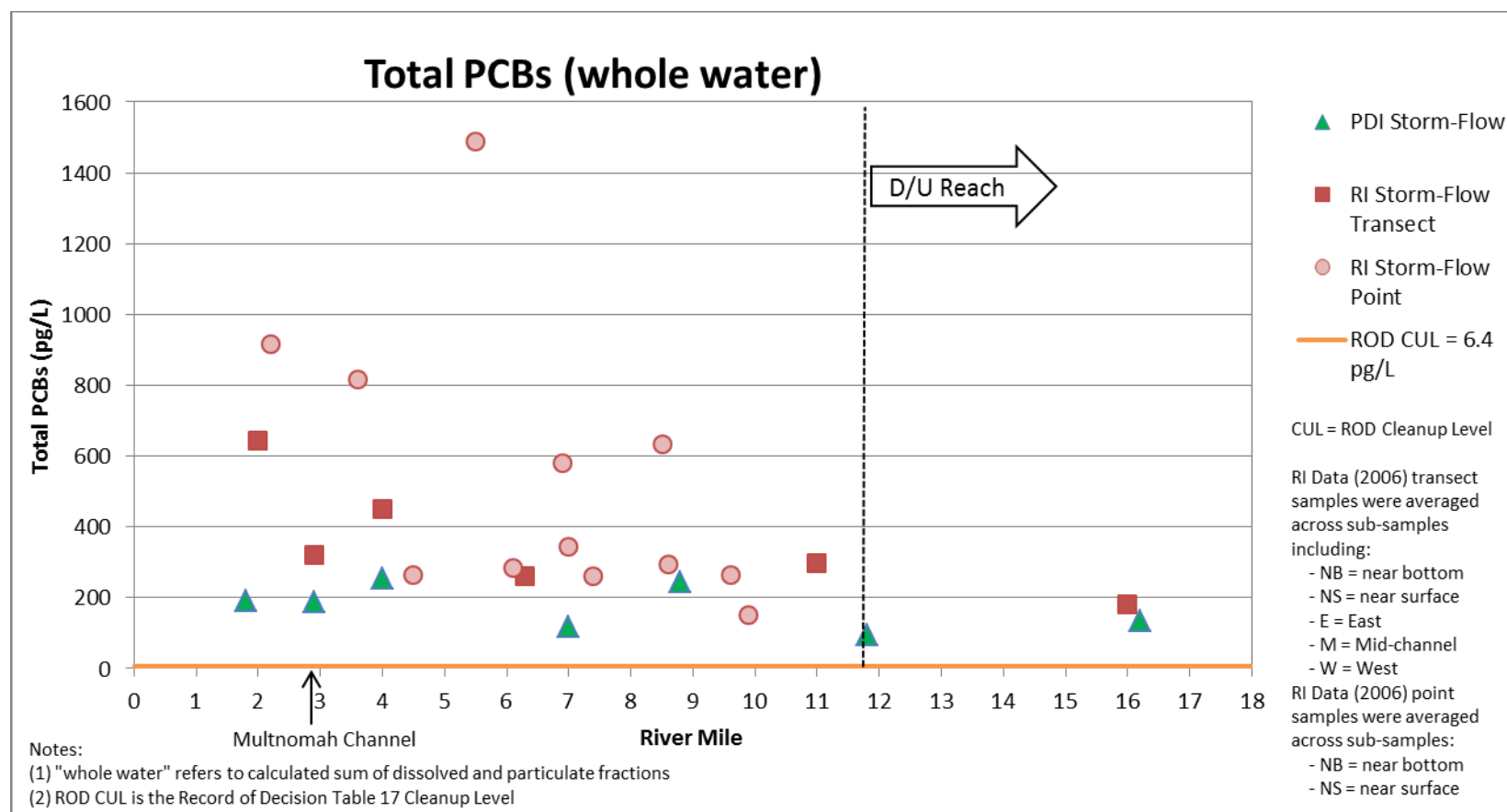
Figure 31. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI). Total PCBs in Whole Water
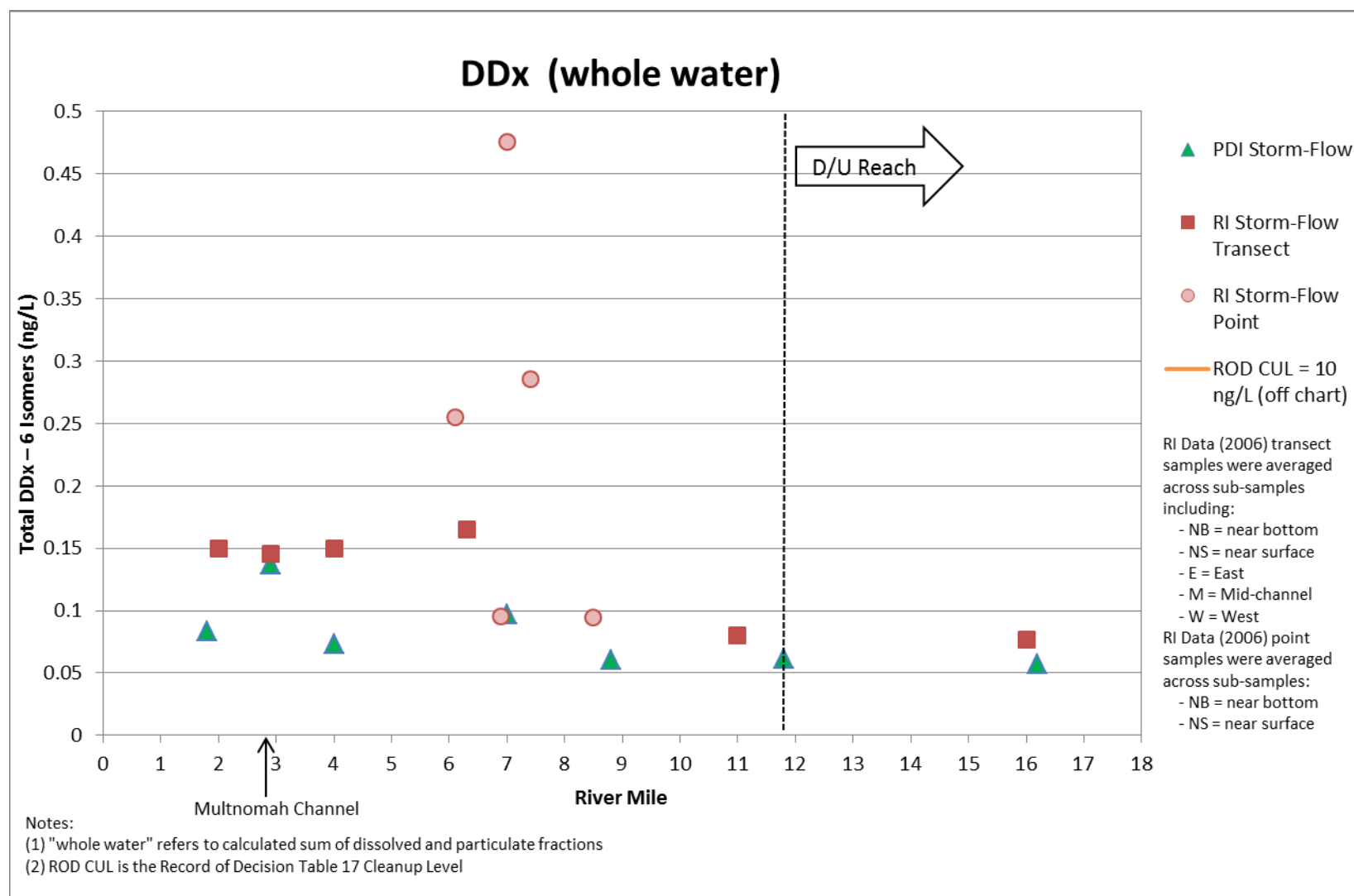
Figure 32. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI). DDx in Whole Water
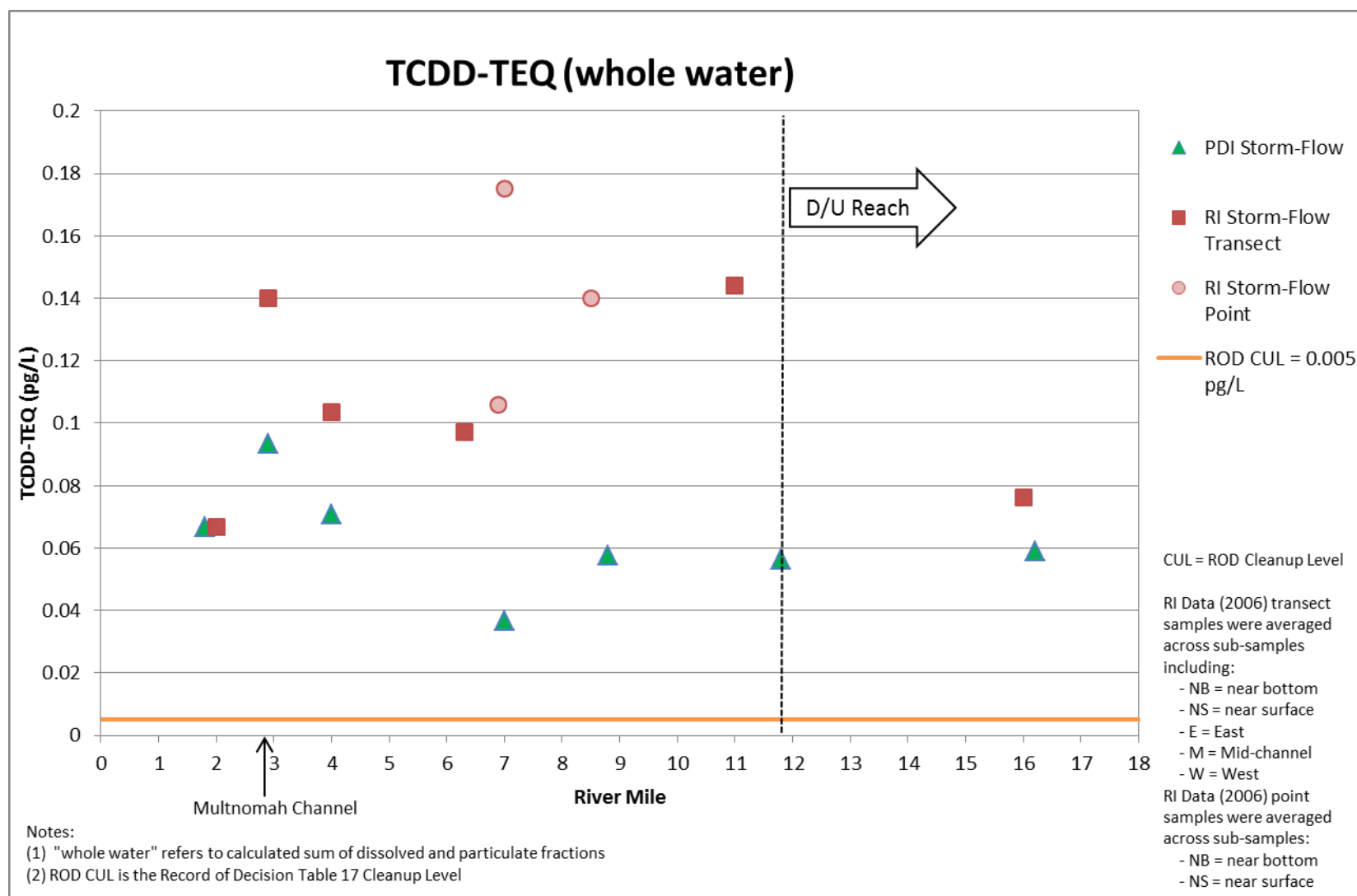
Figure 33. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI). TCDD-TEQ in Whole Water
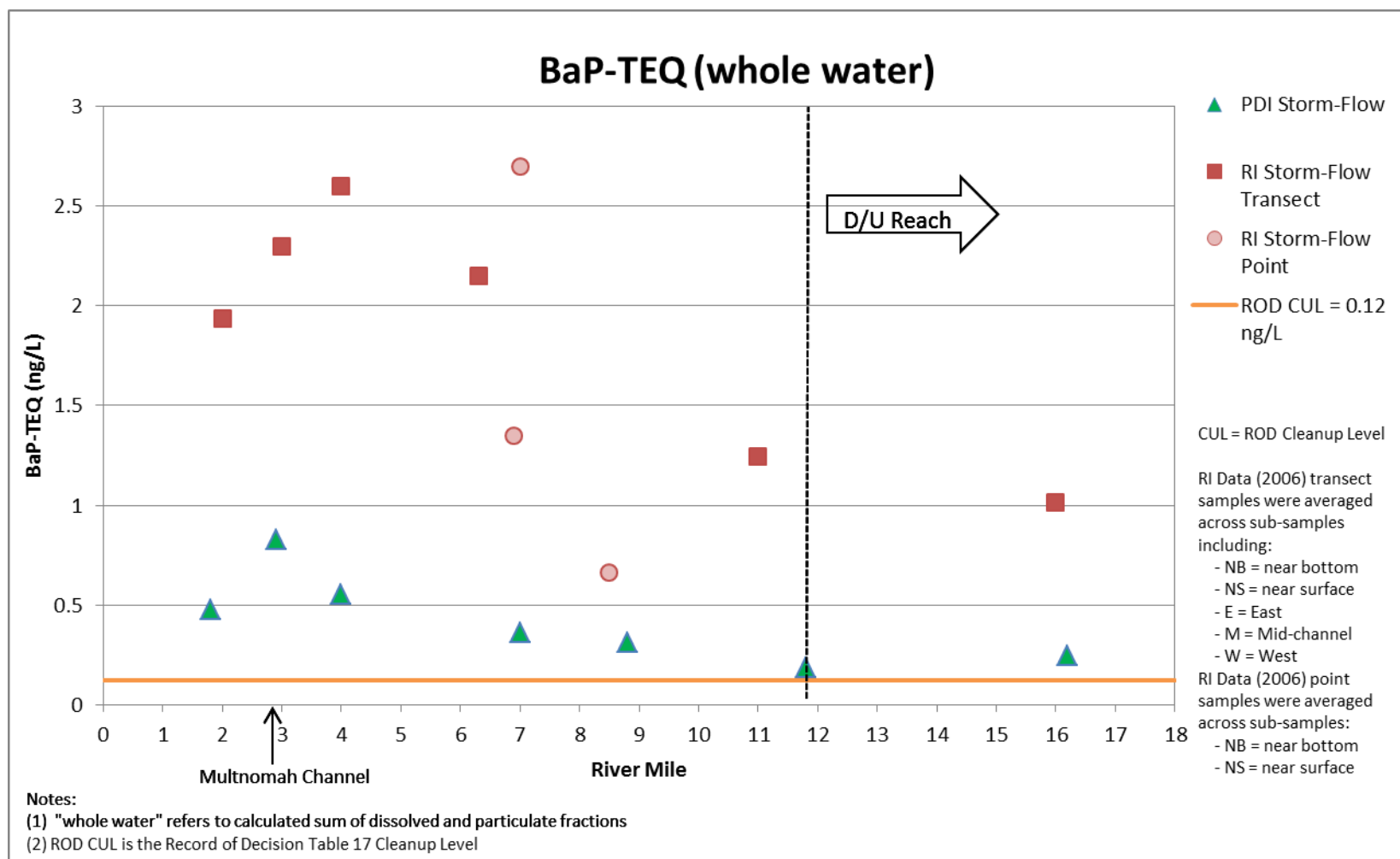
Figure 34. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI). BaP-TEQ in Whole Water
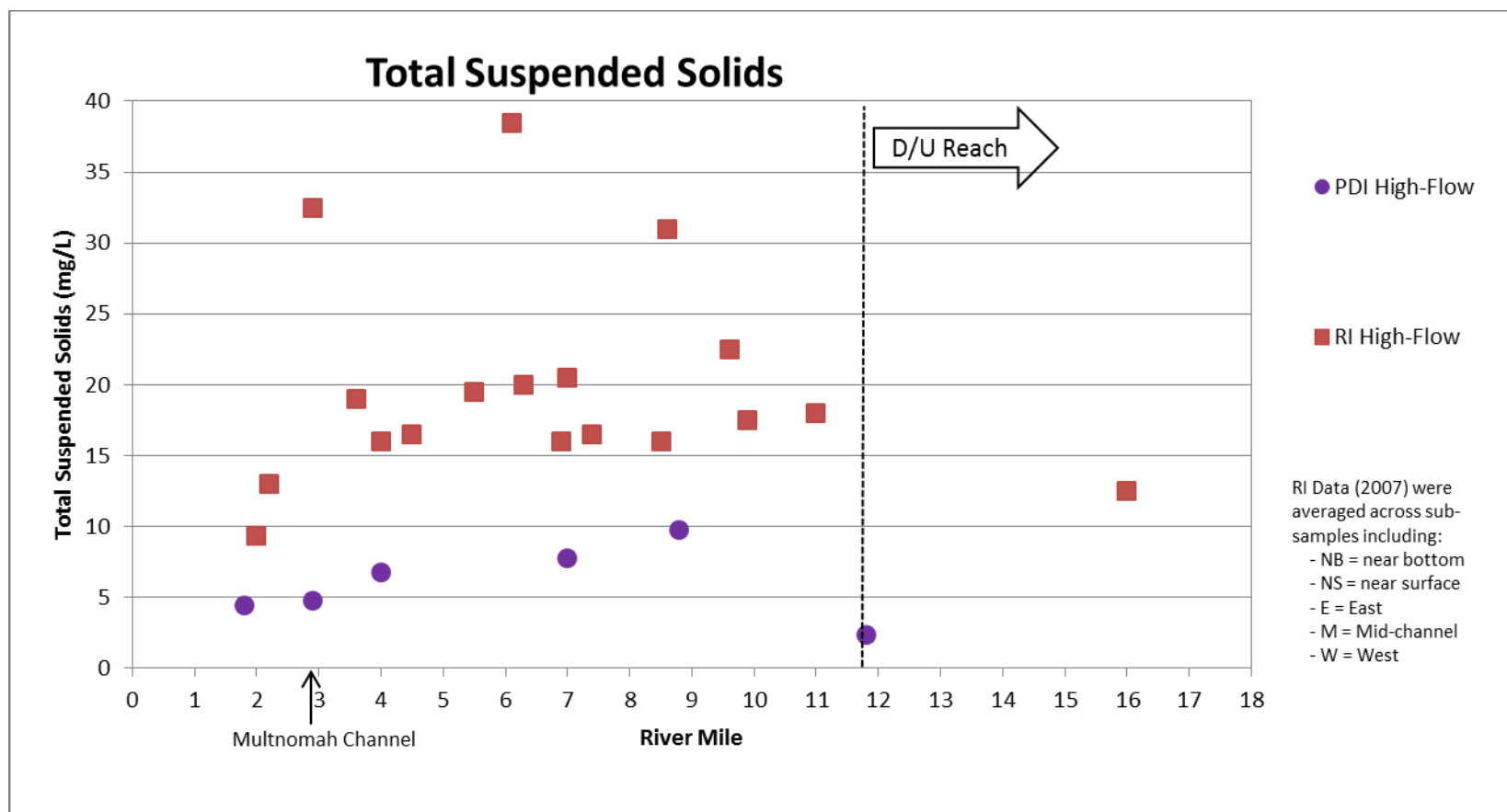
Figure 35. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI). Total Suspended Solids
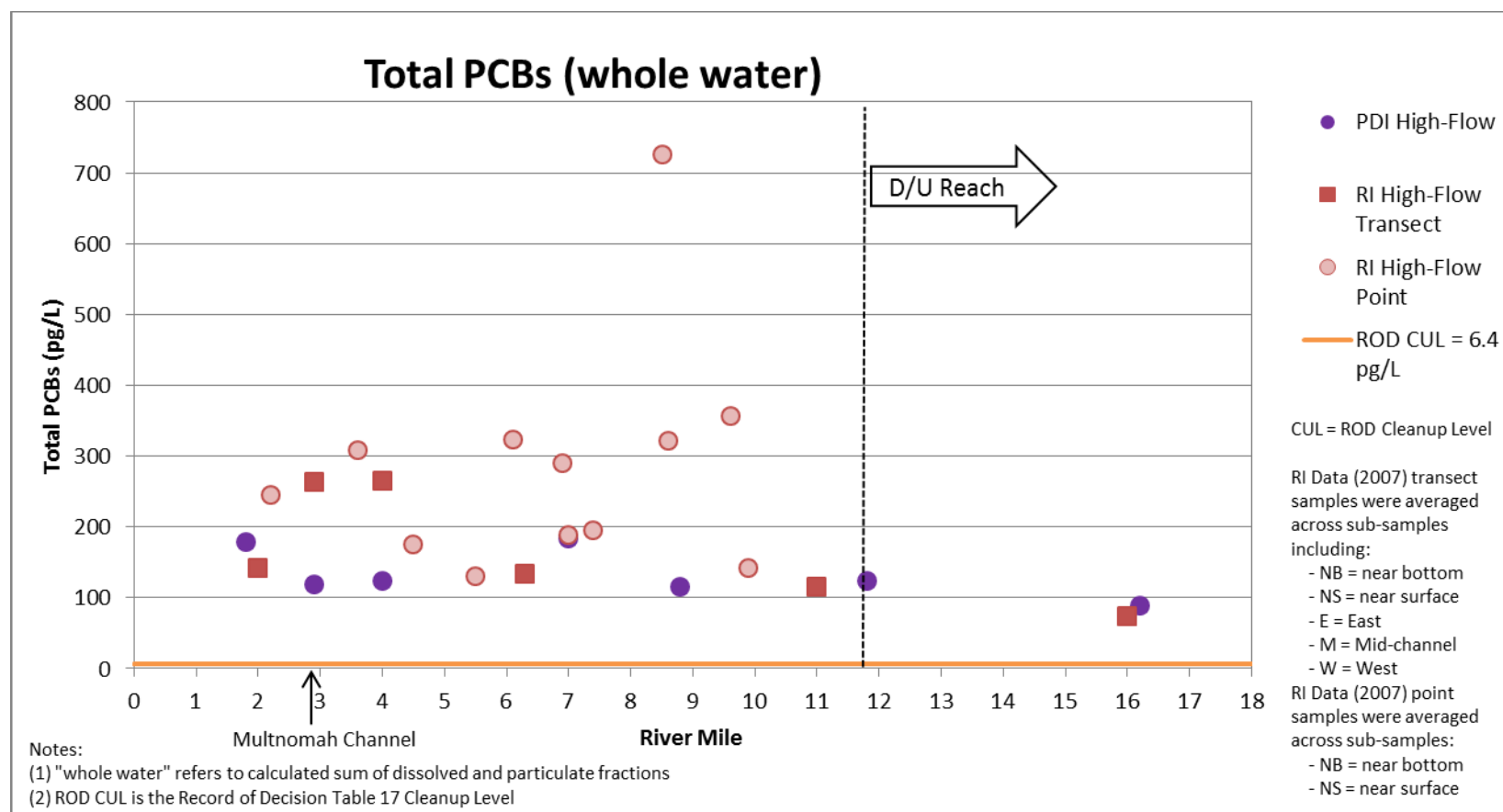
Figure 36. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI). Total PCBs in Whole Water
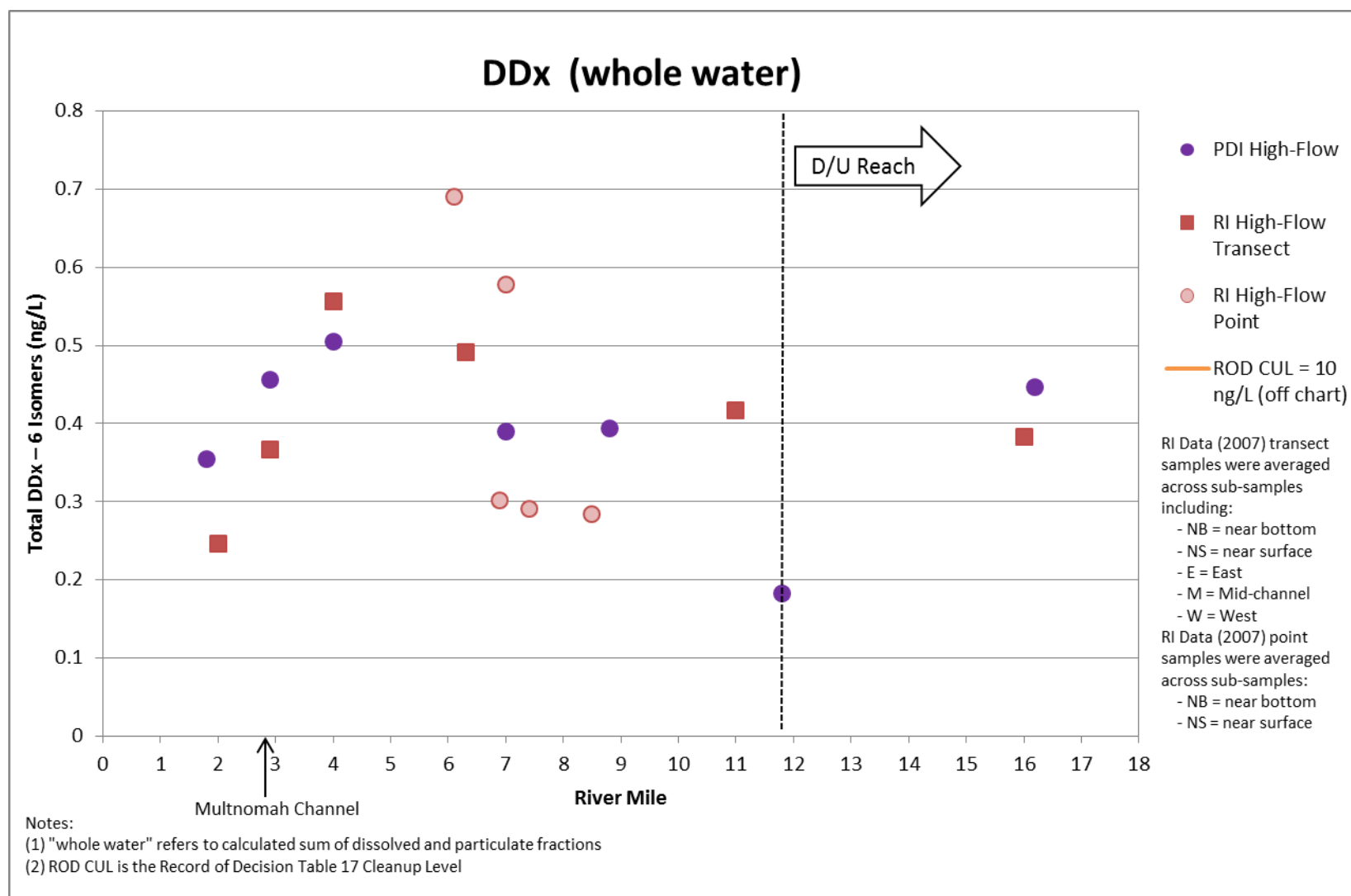
Figure 37. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI). DDx in Whole Water
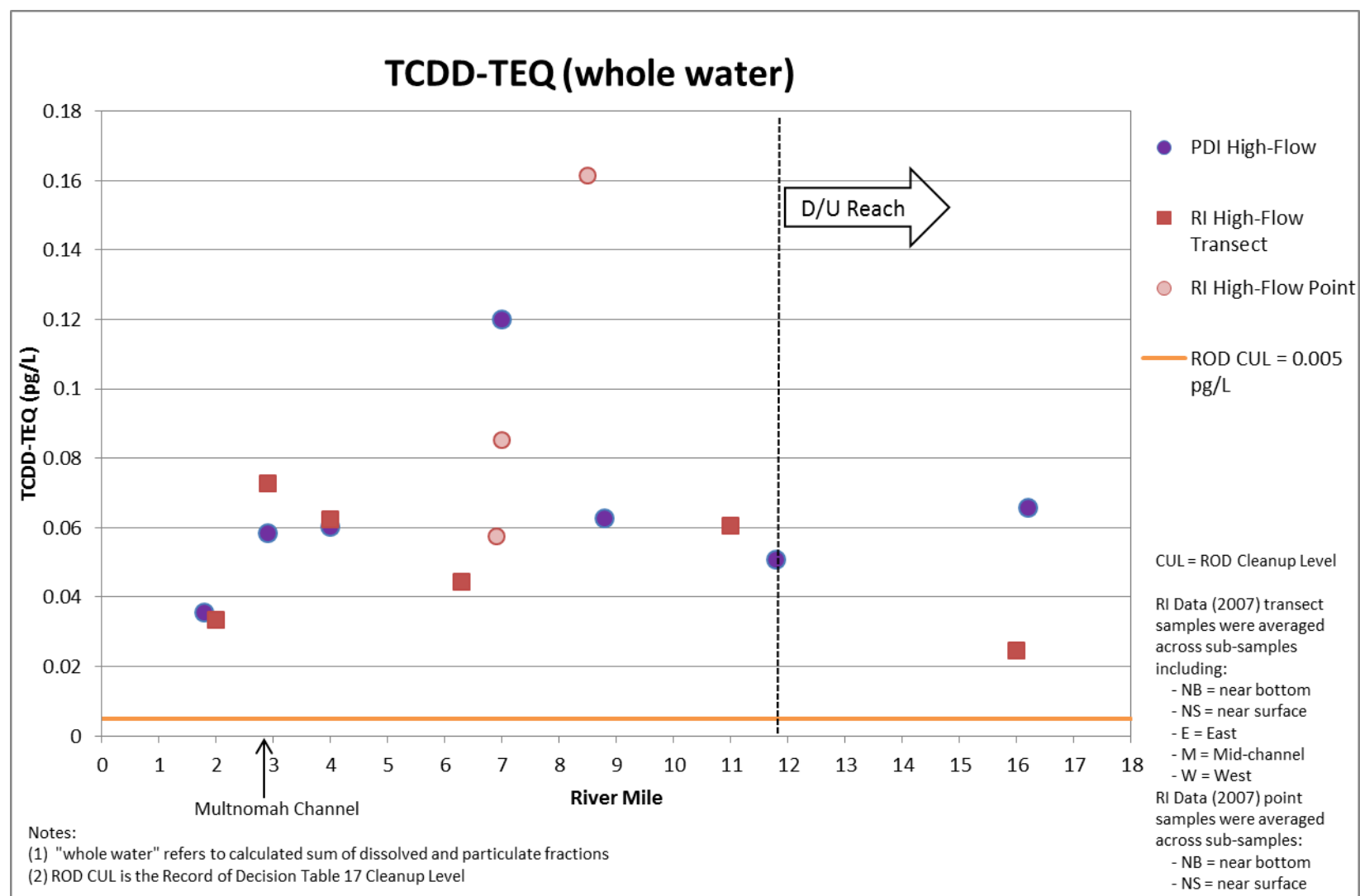
Figure 38. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI). TCDD-TEQ in Whole Water
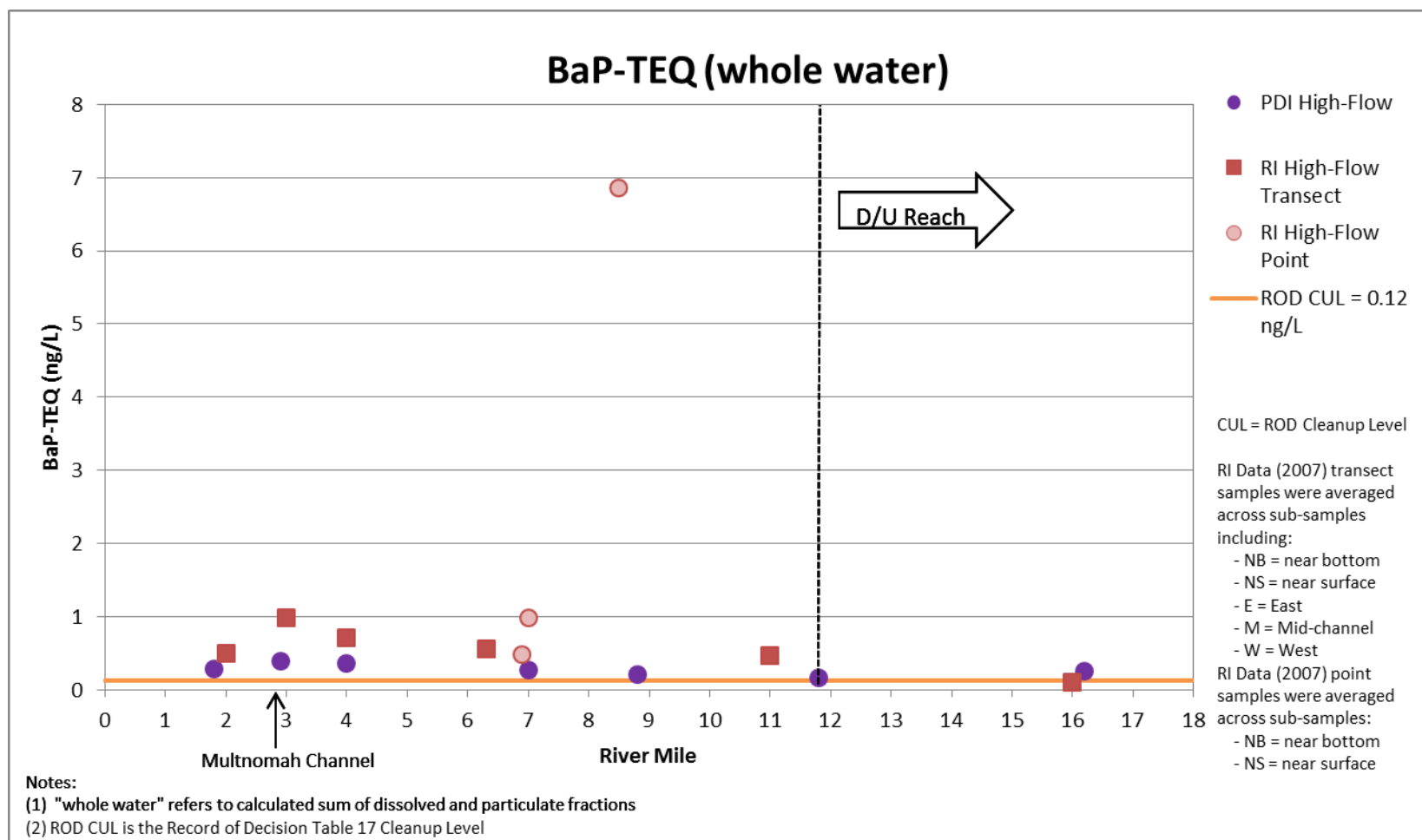
Figure 39. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI). BaP-TEQ in Whole Water

EXHIBITS

EXHIBIT A

Optics Analysis
(Integral)

Optics Analysis

Overview

As described in Appendices B.5 and D.5 and in Change Request 15 (attached), water quality measurements including turbidity, salinity, pH, dissolved oxygen, fluorescence of dissolved organic matter (fDOM), total algae fluorescence, and water depth were collected with a YSI sonde during surface water sampling as part of the Pre-Remedial Design Investigation (PDI). The water quality and optical measurements (fDOM and total algae) collected simultaneously with surface water collection allowed for the correlation of contaminant of concern (COC) concentrations (e.g., polychlorinated biphenyls [PCBs] and dichlorodiphenyltrichloroethane and its derivatives [DDx]) with water quality and optical characteristics of the surface water. The correlations were used to determine predictive relationships between COC concentrations and water quality and optical parameters. These correlations were then applied to estimate COC concentrations from near-continuous time series of water quality and optical parameters measured at the existing surface water monitoring station operated by the United States Geological Survey (USGS) at Morrison Bridge (USGS Station 14211720, dating back to at least July 2016). This provides for estimation of COC concentration for a long-term, near-continuous basis, and supports the surface water component of the conceptual site model by providing a better understanding of real-time variations in surface water COC concentrations across a range of conditions.

The correlation of water quality and optical parameters with COC concentrations allows researchers to track estimated COC concentrations in surface water using the high temporal resolution *in situ* field measurements collected by the USGS. Similar predictions of COC concentrations from water column properties have proven successful at Superfund and state-run sediment sites (Berry's Creek, New Jersey; South River, Virginia; San Francisco Bay Estuary, California; Everglades National Park, Florida). These methods are currently being used at the Lower Passaic River, New Jersey, for a wide range of COCs. This data collection and analysis approach is documented in several peer-reviewed publications (Bergamaschi et al. 2011,[1] 2012a,[2]

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[1] Bergamaschi, B.A., J.A. Fleck, B.D. Downing, E. Boss, B. Pellerin, N.K. Ganji, D.H. Schoellhamer, A.A. Byington, W.A. Heim, M. Stephenson, and R. Fujii. 2011. Methyl mercury dynamics in a tidal wetland quantified using in situ optical measurements, *Limnology and Oceanography*, 56: 1355-1371.

[2] Bergamaschi, B.A., J.A. Fleck, B.D. Downing, E. Boss, B.A. Pellerin, N.K. Ganju, D.H. Schoellhamer, A.A. Byington, W.A. Heim, M. Stephenson, and R. Fujii. 2012a. Mercury dynamics in a San Francisco estuary tidal wetland: Assessing dynamics using in situ measurements, *Estuaries and Coasts*, 35: 1036-1048.

2012b;[3] Chang et al. 2018,[4] 2019[5]) and was extensively evaluated and accepted through an official United States Environmental Protection Agency (EPA) peer review.

Data Analysis

As described in Appendix D.5, surface water sampling was conducted over three events (low flow, high flow, and storm flow) using both high-volume and peristaltic pump techniques at seven transect locations throughout the Site. During the surface water sampling, optical and water quality field parameters were measured using a multi-probe YSI sensor (depth, temperature, pH, dissolved oxygen, turbidity, and conductivity). As described in Change Request 15, the YSI multi-probe also had fDOM and total algae sensors (optical measurements). All of the *in situ* measurements were collected at a frequency of once per minute throughout surface water sampling.

The collected water quality and optical measurements were processed for each transect location by removing any measurement values that were more than three standard deviations away from the average value. Using this method, less than 3% of the outlier data for any given parameter and transect location was removed. The average measured parameter across the transect location (east, navigation, and west) was computed for all measured water quality and optical parameters for parity with the COC samples, which were composited across each transect.

The average water quality and optical parameters were compared to COC sample concentrations to develop predictive relationships between water quality/optical parameters and COC concentrations. The predictive relationship for each COC was then applied to measured water quality and optical parameters at the Morrison Bridge USGS gage station to develop near-continuous time series estimates of COC concentrations upstream of the Site.

This analysis was conducted for the focused COCs total PCBs and DDx, as well as benzo[a]pyrene (BaP) toxicity equivalent (TEQ)[6] and tetrachlorodibenzo-p-dioxin (TCDD) TEQ. Total suspended solids (TSS) concentrations were also evaluated, although two TSS samples that were reported below detection limits were not included in this analysis. The data processing and correlation analysis was conducted using a partial least squares (PLS) regression. Using this method, the linear regression is determined by projecting the measured COC concentrations and selected water quality and optical parameters using principal component analysis. The number of components for

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[3] Bergamaschi, B.A., D.P. Krabbenhoft, G.R. Aiken, E. Patino, D.G. Rumbold, and W.H. Orem. 2012b. Tidally driven export of dissolved organic carbon, total mercury, and methylmercury from a mangrove-dominated estuary, *Environmental Science and Technology*, 46: 1371-1378.

[4] Chang, G., T. Martin, K. Whitehead, C. Jones, and F. Spada. 2018. Optically-based quantification of fluxes of mercury, methyl mercury, and polychlorinated biphenyls (PCBs) at Berry's Creek tidal estuary, New Jersey, *Limnology and Oceanography*, 34: 1143-1141. doi: 10.1002/rra3361.

[5] Chang, G., T. Martin, F. Spada, B. Sackmann, C. Jones, and K. Whitehead. 2019. Optically-based quantification of fluxes of mercury and methylmercury in South River, Virginia (USA), *River Research and Applications*, 64:93-108. doi: 10.1002/lno.11021.

[6] As described in Appendix D.5, polycyclic aromatic hydrocarbons (PAHs) are presented as BaP-TEQ because the ROD established a CUL for BaP-TEQ in surface water, not PAHs. Therefore, BaP-TEQ is used throughout this analysis.

the projected data are carefully chosen to ensure the regression is not over constrained. The resulting linear regression of projected data provides coefficients such that the predicted concentration of a given COC, C_pred, can be estimated using:

$$C_{pred} = b + \sum_{i=1}^{N} \beta_i P_i$$

where b is a linear offset, P_i is an optical or water quality parameter, β_i is a computed coefficient, and N is the number of water quality and optical parameters in the analysis. The predictive relationship for each focused COC is defined by the coefficients, β_i, for each optical parameter used in the linear combination. The goodness of the predicted fit is computed with the R-squared value given by:

$$R^2 = 1 - \frac{\sum(C - C_{pred})^2}{\sum(C - \bar{C})^2}$$

where C is the measured COC concentration, C_pred is the predicted COC concentration, and $\bar{C}$ is the average COC concentration. The normalized root mean square error (NRMSE) can also be used to evaluate the magnitude of predicted COC concentration error using:

$$NRMSE = \frac{\sqrt{\sum(C - C_{pred})^2}}{\bar{C}}$$

The selection of water quality and optical parameters resulting in the highest R-squared value using the lowest number of components was selected for each COC. Figure 1, below, shows the measured and predicted (using the measured water quality and optical parameters) values for each of the constituents as well as the computed R-squared value, indicating the strength of the predictive relationship. The R-squared value, number of PLS regression components, and the NRMSE values for each COC are shown in Table 1. The resulting coefficients from the analysis for each COC and water quality/optical parameter are shown in Table 2.

The analysis indicates that, for the range of conditions evaluated during the study, the correlation between *in situ* water quality/optical parameters and measured COC concentrations provides a reliable and robust method for estimating the surface water concentrations for the majority of the COCs considered. The R-squared value for total PCBs, DDx, and BaP-TEQ was greater than 0.69, indicating a good fit between predicted and measured COC concentrations. The R-squared value for TCDD-TEQ was 0.2, indicating a poor fit between measured and predicted concentrations. This moderate fit for TCDD-TEQ is related to several factors, including the range of concentrations measured. The measured concentrations for TCDD-TEQ are relatively low and fall within a limited range (only 0.1 picogram per liter separates the maximum and minimum reported values). The correlation analysis typically generates better results when there is a broader range of measured concentrations. In addition, TCDD-TEQ is a computed value and, for the dataset,

includes substantial qualified individual congener data (JN and J+ qualifiers). Many of the sample results for the individual congeners are at or near detection limits. Thus, there is uncertainty in the calculated TCDD-TEQ values. Because the predictive relationship is unable to account for this uncertainty, the predicted TCDD-TEQ concentration at Morrison Bridge using measured parameters is also highly uncertain. Additionally, using the computed TCDD oxin and furan congeners, which may result in better predictive relationships than those for the computed TEQ concentrations. However, due to the high proportion of qualified dioxin and congener data (between 43% and 100% of the whole water congener concentrations are qualified), this analysis was not conducted.
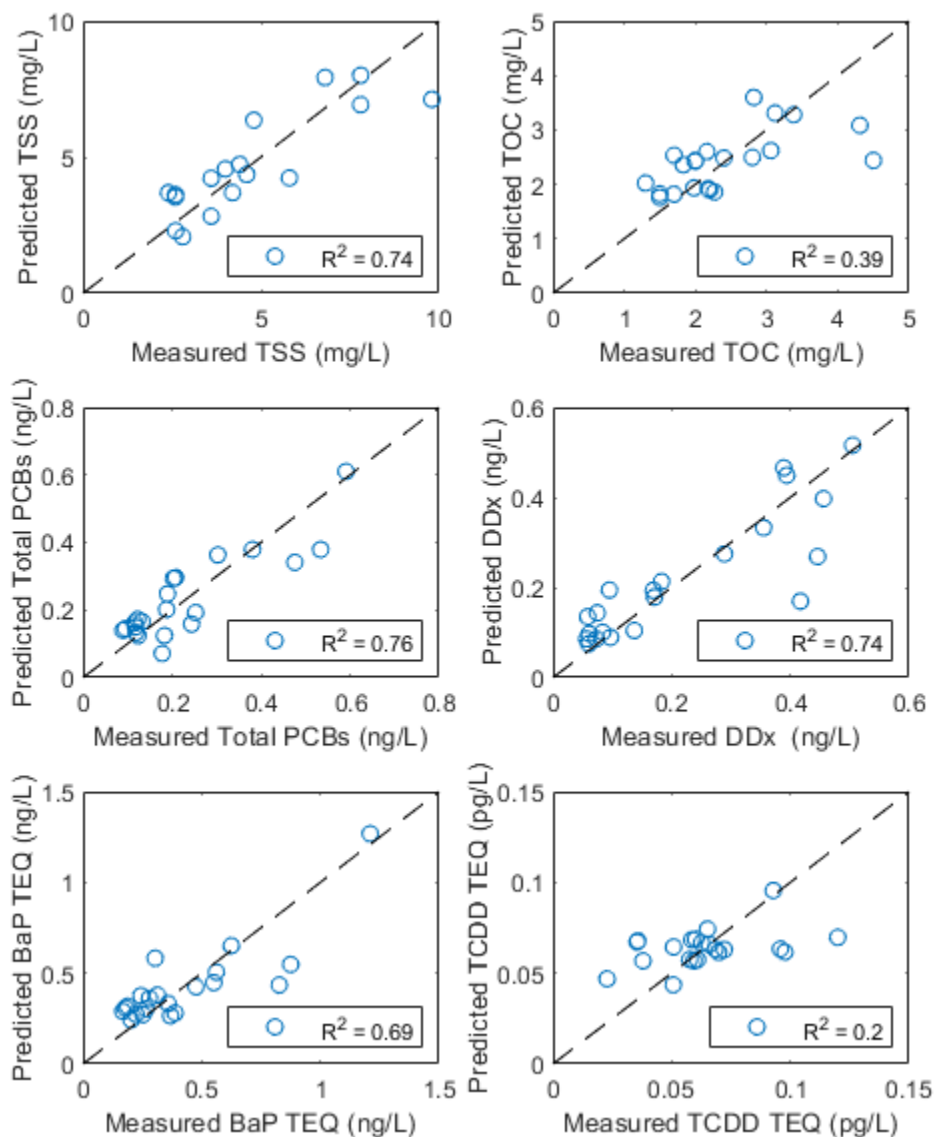
Figure 1. Predictive relationship for various measured constituents using water quality and optical parameters.

Table 1. Results of PLS regression for focused COCs including the R-squared value, NRMSE, and number of components.

	TSS (mg/L)	Total PCBs (pg/L)	DDx (ng/L)	BaP-TEQ (ng/L)	TCDD-TEQ (pg/L)
Number of Components	4	3	3	4	4
R-squared value	0.74	0.76	0.74	0.69	0.20
NRMSE	0.95	1.39	1.67	1.61	1.45

Table 2. Focused COCs and optical parameter coefficients used in each predictive relationship from the PLS regression.

	TSS (mg/L)	Total PCBs (pg/L)	Total DDx (ng/L)	cPAH TEQ (ng/L)	TCDD TEQ (pg/L)
Turbidity (FNU)	0.238	0.005	0.015	-0.007	0.000
Specific Conductivity (µS/cm)	0.009	0.001	0.000	0.002	0.000
Chlorophyll (µg/L)	-0.087	0.010	0.006	0.057	0.004
fDOM (QSU)	-0.186	-0.014	-0.004	0.006	-0.001
pH	-0.059	0.001	0.000	0.065	0.006
Phycocyanin (RFU)	-0.009	0.000	0.000	0.015	0.004
Dissolved Oxygen (mg/L)	0.008	-0.009	-0.003	0.012	0.005
Offset (*b*)	4.354	0.407	0.131	-0.591	-0.047

Predicted COC Concentrations

The optical parameters and coefficients used to predict COC concentrations shown in Table 2 can be applied to measurements of water quality and optical parameters collected in the absence of surface water sample collection. As described above, the USGS monitoring station at Morrison Bridge has recorded the same water quality and optical properties that were measured as part of the surface water sampling event. The predictive relationships unique to each focused COC can then be used to predict the long-term concentrations upstream of the Site from the Morrison Bridge USGS monitoring station. The time series for a subset (back to October of 2017) of the available record of measured water quality and optical parameters and river flow data are shown in Figure 2, below. The water quality and optical parameter data were used to derive predicted concentrations of TSS, total PCBs, DDx, and BaP-TEQ, as shown in Figure 3.

As expected, the predicted TSS concentrations increase when Willamette River discharge and turbidity increase. While discharge was not included in the predictive relationships for TSS or the focused COCs, it is a primary driver of dynamics within the Willamette River and many optical parameters and constituents are related (or inversely related) to discharge. Predicted total PCBs and BaP-TEQ concentrations are greatest during low flow periods over summer months and are well correlated with measured chlorophyll and fDOM. The predicted concentrations of these COCs tend to be low during high-flow periods, consistent with surface sampling observations. The

concentration of DDx tends to increase during high-flow periods and correlates with periods of high TSS.
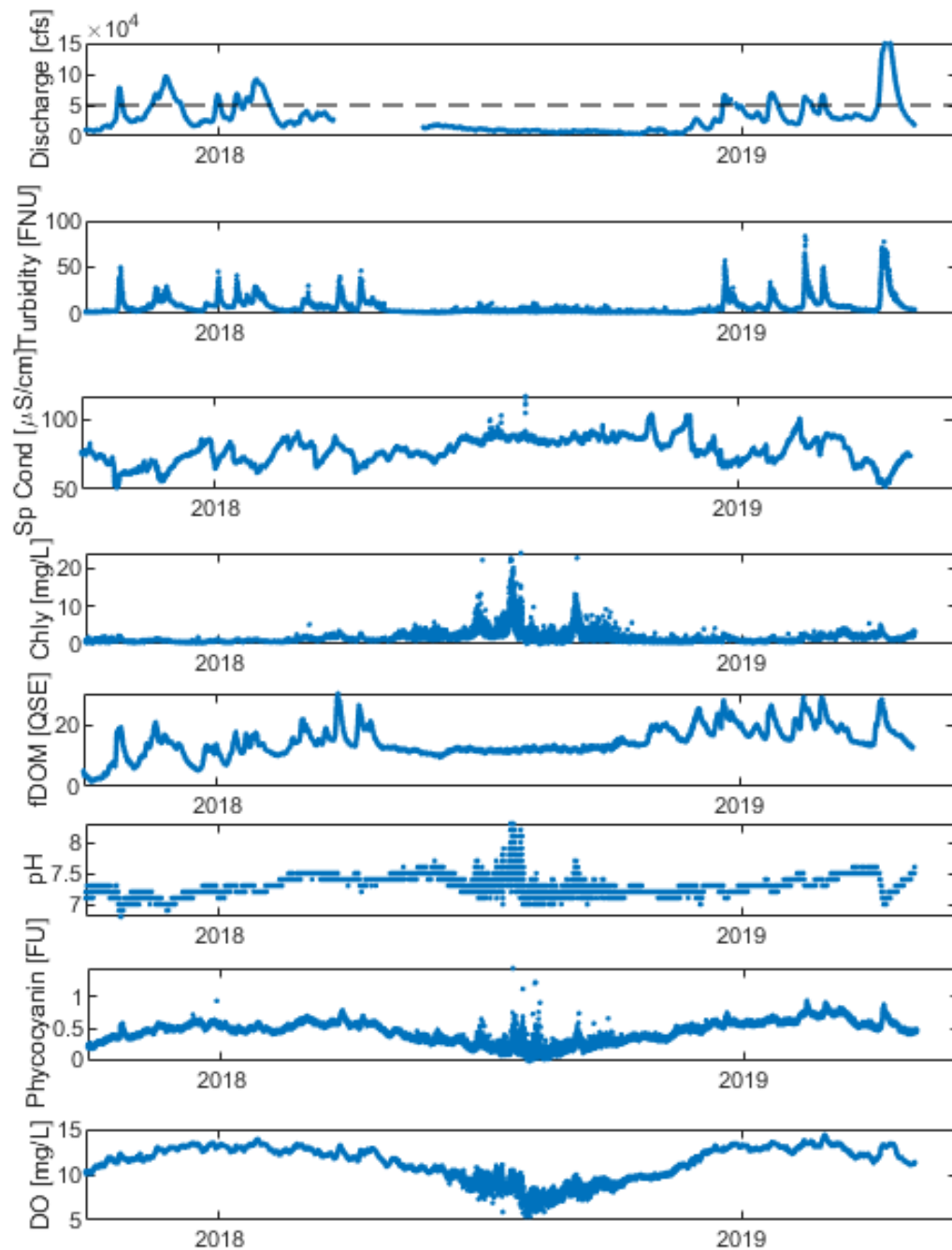

Figure 2. Measured parameters at the USGS monitoring station located at Morrison Bridge in Portland, Oregon (USGS Station 14211720). The threshold criteria for high flow (50,000 cubic feet per second [cfs]) is indicated in the top panel with the black dashed line.
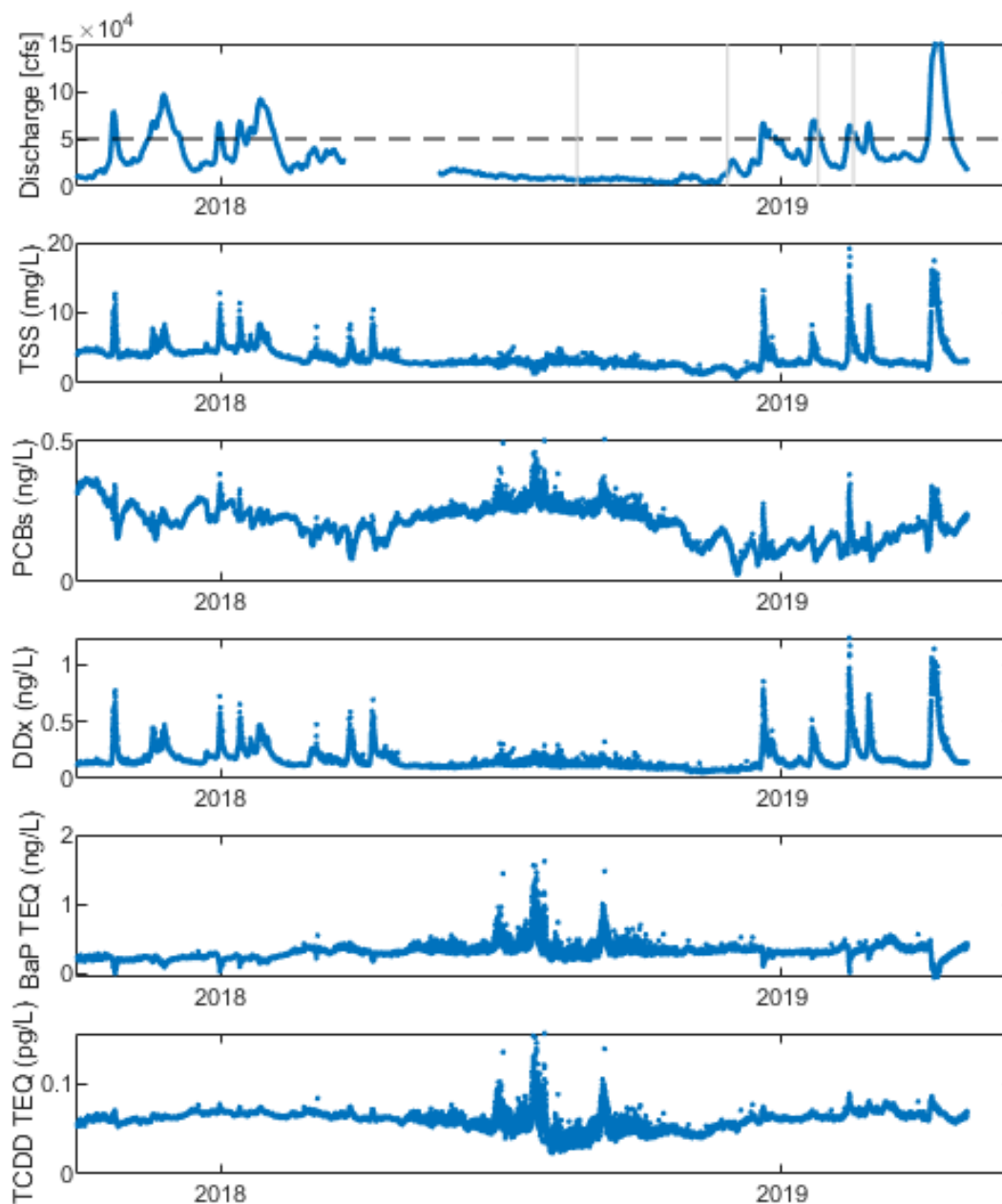
Figure 3. Measured discharge from Morrison Bridge is shown in the top panel with sampling events indicated by the gray lines and the 50,000 cfs threshold for high flow events indicated with black dashed line. The predicted concentrations of TSS, total PCBs, DDx, and BaP-TEQ are shown in the remaining panels. Predicted TCDD-TEQ concentrations are not shown.

Summary and Conclusions

In summary, *in situ* water quality and optical measurements were collected simultaneously during the surface water sampling. For each of the seven sampling transects and for each sampling event (low flow, high flow, and storm flow), the average of the measured water quality and optical parameter values were correlated with measured TSS and focused COC concentrations. The

analysis yielded R-squared values exceeding 0.69 for TSS, total PCBs, DDx, and BaP-TEQ. This indicates that, for the range of conditions evaluated during the study, *in situ* water quality/optical parameters can be used to provide a reliable and robust method for estimating the surface water concentrations for these constituents. The exception is for TCDD-TEQ. Due to limitations associated with the TCDD-TEQ analytical data set (e.g., limited range and low concentrations, frequently qualified results, concentrations at or below the analytical detection limit), the predicted TCDD-TEQ concentrations have a high degree of uncertainty. As described above, a better predictive fit may be possible for individual dioxin and furan congeners. However, due to the significant percentage of qualified data (between 44% and 100% of individual congeners in whole water were qualified, as described in Appendix D.5), this analysis was not conducted.

The predictive relationship between *in situ* measured water quality and optical parameters and surface water concentrations of TSS and COCs was applied to the measured water quality data available at the USGS monitoring station at Morrison Bridge to develop time series of TSS and estimated COC concentrations (Figure 3) across the period of available data from the USGS station. Trends in predicted COC concentrations indicate that total PCBs and BaP-TEQ tend to increase during low flow periods. Predicted concentrations of DDx are also higher during some low flow periods. However, unlike total PCBs and BaP-TEQ, DDx concentrations were also predicted to increase during higher flow periods with higher TSS, typically related to storm-flow events. Similar patterns were observed in the analytical data set from the PDI surface water sampling. This indicates that a different mechanism(s) is influencing the surface water concentration of DDx upstream of the Site than are influencing the surface water concentrations of total PCBs and BaP-TEQ, particularly during storm-flow events.

EXHIBIT B

Method for Calculation of Whole Water Concentrations

To: Kenneth Tyrrell, AECOM   AECOM Project No.: <u>60566335</u>

From: Kristen Durocher, AECOM   Date: January 31, 2019

Project: Portland Harbor Pre-Remedial Design Investigation and Baseline
         Sampling CERCLA Docket No. 10-2018-0236

Subject: Methodology for Calculating Whole Water Concentrations from High Volume XAD and Solids Data

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This memorandum describes the methodology to be used to calculate whole water concentrations from the surface water samples collected using the high volume (HV) sampling methods for the Portland Harbor Pre-Remedial Design Investigation (PDI). The database management and summation rules to be used for the HV surface water results are also described.

The PDI HV sampling involves passing large volumes of water through a system that collects a particulate phase on physical filters and a dissolved phase[1] on a sorbent (i.e., XAD resin). Data are reported by the analytical laboratory (SGS-AXYS) in units of mass per sample (e.g., picograms per sample [pg/sample] or nanograms per sample [ng/sample]). These data are converted from mass per sample to mass per volume, and the dissolved and particulate concentration fractions are then summed to yield the whole water concentration of each HV analyte in a sample. For the PDI, this includes the following contaminants of concern: dioxin and furan congeners, polychlorinated biphenyl (PCB) congeners, organochlorine pesticides and hexachlorobenzene, and polycyclic aromatic hydrocarbons (PAHs).

Calculation of Whole Water Concentrations

The following steps will be used to convert the data from the units reported by the laboratory to mass per liter units (i.e., pg/L or ng/L) and estimate whole water concentrations.

1. Conversion of Dissolved and Solid Fractions from Mass per Sample to Mass per Liter

Dissolved Phase

XAD samples represent the dissolved fraction of constituents in the surface water. For each chemical result, the mass of chemical per sample will be multiplied by the volume of water passed through the XAD to calculate the dissolved phase concentration as mass per liter.

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[1] The "dissolved phase" refers to the dissolved fraction operationally defined by the filtration process and analyte retention on the XAD resin.

As example, in PDI-WS-T01-1808 collected at Transect 01 on August 24 - 25, 2018, PCB-3 is reported as 178 pg/sample in the XAD. A total of 402 liters of water was sampled at Transect 01 on this event. The concentration of dissolved phase PCB-3 in this sample is calculated as:

$$\frac{concentration\ (mass\ per\ sample)}{volume\ of\ water\ sample\ (liters)} = concentration\ (mass\ per\ liter)$$

178 pg/sample ÷ 402L = 0.443 pg/L

<u>Solids Fraction</u>

For the solids fraction (particulates collected on the filters), the same mathematical conversion applies. Due to the large number of filters used in the Round 1 sampling event (Low Flow, August 2018), the analytical laboratory (SGS-AXYS) was not able to analyze all the filter mass as a single sample. The filters and separated solids were thoroughly homogenized and weighed. The laboratory took a sub-sample consisting of 20% of the total filter mass after homogenization of all filters used per sample. The sample size used for all analyses to quantify the 20% filter portion in batch WG65583 was 0.2, so the results on a mass per sample basis reported by the lab accounted for this split factor.[2]

The detection limits reported during the low-flow event were also impacted by the mass of sample analyzed. The adjustment the laboratory made to the sample size to account for the filter mass (i.e., sample size = 0.2) which elevated the detection limits approximately 5-fold compared to the storm-flow event, where the complete set of filter used was analyzed (i.e., sample size = 1). However, as with the detected samples, the quantitation limits reported by the laboratory for samples below detection limit accounted for the filter fraction.

In Sample PDI-WS-T01-1808, PCB-3 is reported as <62.3 pg/sample in the solids. The concentration of solid phase PCB-3 in this sample is calculated as:

$$\frac{concentration\ (mass\ per\ sample)}{volume\ of\ water\ sample\ (liters)} = concentration\ (mass\ per\ liter)$$

<62.3 pg/sample ÷ 402L = <0.155 pg/L

2. Estimation of Whole Water Concentrations from Fractional Lab Matrix Concentrations

Conversion of individual matrix concentrations to a whole water concentration will follow the method used in the 2016 Remedial Investigation (RI). As described in Section 5.4.1 of The RI (EPA, 2016), "….a summed XAD concentration was calculated from the XAD column and XAD filter[3] concentrations. In this sum, non-detects were set to zero. If both XAD fractions were non-detect, the summed detection limit was set to the sum of the individual detection limits."[4]

For PDI-WS-T01-1808, the concentration of PCB-3 in dissolved phase ("XAD column") is 0.443 pg/L and the concentration in the solids fraction ("XAD filter") is <0.155 pg/L. Following the RI method, the whole water concentration is calculated as:

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[2] Email dated January 16, 2019, from Sean Campbell of SGS-AXYS to Robert Kennedy and Paula DiMattei of AECOM.

[3] "XAD filter" fraction referred to in the RI is equivalent to the solids or particulate fraction (terms used in PDI).

[4] The potential impact of using summed detection limits can be evaluated as part of data analysis for the surface water data set (e.g., use of the higher detection limit of the two fractions vs. summed detection limits).

0.443 pg/L + 0 pg/L = 0.443 pg/L

Examples of the three different calculations are provided in the table below. Each example represents one of the PCB congener results for PDI-WS-T01-1808. The first example is when both fractions are detected (PCB-209). The second example is when both fractions are not detected (PCB-106). The third example is when one fraction is detected and the other fraction is not detected (PCB-3) (also provided in the example calculations above).

Medium	Concentration (pg/sample)	Volume of Water per Sample (L/sample)	Concentration (pg/L)
PCB 209 (both fractions detected)			
XAD	12.5	402	0.031
Filters	256	402	0.637
Whole Water			0.668
PCB 106 (both fractions not detected)			
XAD	<5.27	402	<0.013
Filters	<8.21	402	<0.020
Whole Water			<0.034
PCB 3 (one fraction detected; one fraction not detected)			
XAD	178	402	0.443
Filters	<62.3	402	<0.155
Whole Water			0.443

3. Data Management and Summation Rules

The data for each HV analyte will be stored in the database as follows:

A. "dissolved" fraction reported by laboratory in mass/sample

B. "dissolved" fraction calculated using surface water sampling volume in mass/L

C. "particulate" fraction reported by laboratory in mass/sample

D. "particulate" fraction calculated using surface water sampling volume in mass/L

E. Whole water (calculated concentration using above [B+D]) in mass/L

To store and track these components in the project database, the following fields will be used:

Database Field	Dissolved fraction from lab (mass/sample)	Dissolved fraction calculated (mass/L)	Particulate fraction from lab (mass/sample)	Particulate fraction calculated (mass/L)	Whole water (mass/L)
MATRIX_CODE	WS	WS	WS	WS	WS
LAB_MATRIX_CODE	XAD[a]	XAD[a]	F[a]	F[a]	XAD+F[a]
FRACTION	D	D	PRT	PRT	T[a]
RESULT_TYPE_CODE	TRG	CALC	TRG	CALC	CALC
Notes:					
(a) These are new values for this field that will be added to the database.					

When a concentration is converted from mass/sample to mass/L, all information stays the same except the UNITS.

This plan slightly deviates from the description presented in the QAPP and FSP; however, the use of 'LAB_MATRIX_CODE' as well as 'MATRIX_CODE' fields provides a more complete description of the components that comprise each surface water sample.

Equipment / rinsate blank samples will be converted into a mass per liter concentration, but the two fractions will not be combined for a whole water concentration.

For sums and toxicity equivalence (e.g., Total PCBs and TCDD-TEQ), calculations will be performed on dissolved, particulate, and whole water concentrations using EPA Region 10's data summation rules for the PDI, with clarifications in AECOM's August 31, 2018, data summation memorandum.[5]

Analytical results reported by the laboratories are maintained in the database as text values in the format received from the reporting laboratories. The number of significant figures provided by the laboratories will not be lost by either the addition or removal of trailing zeros. When converting data or summing for totals, all significant figures will be carried through the calculations.

4. Calculation of Surface Water COPC Particulate Concentrations

Surface water particulate data were also calculated on a dry weight basis for comparison to sediment data (summarized in data tables, but not included in the database). Whole water COPC concentrations (mass per L basis) were divided by sample-specific TSS (mg/L) to obtain a concentration of mass COPC per mg TSS.

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[5] See EPA's Data Summation Rules (December 12, 2017) and AECOM Memorandum: Summary of Data Summation Rules for Pre-Design Investigation (August 31, 2018). Both documents are provided in Appendix C.3 of the PDI Evaluation Report.

EXHIBIT C

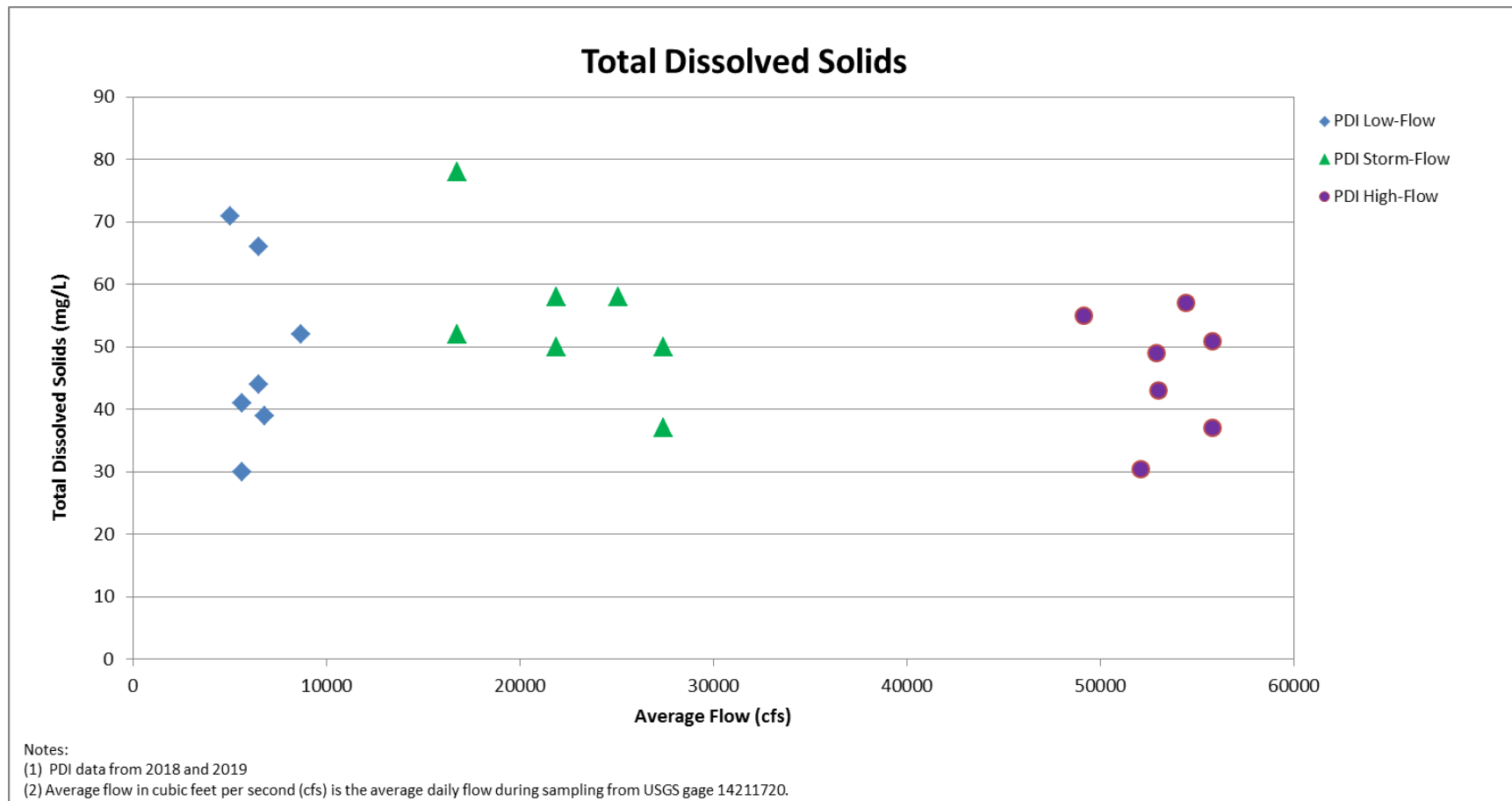Concentrations of COC from PDI Sampling by Discharge

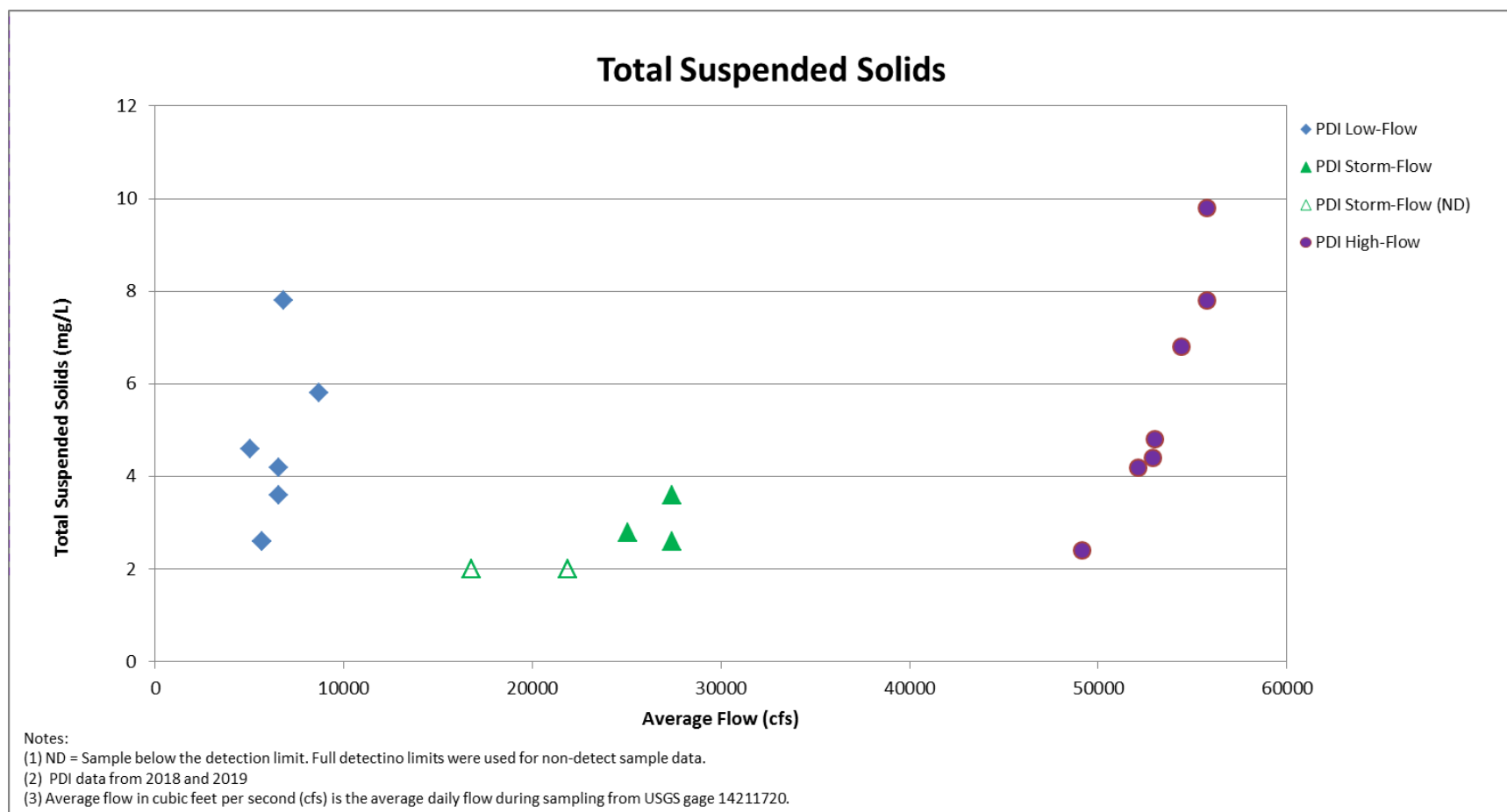Figure C-1. Concentrations of Total Dissolved Solids by Discharge

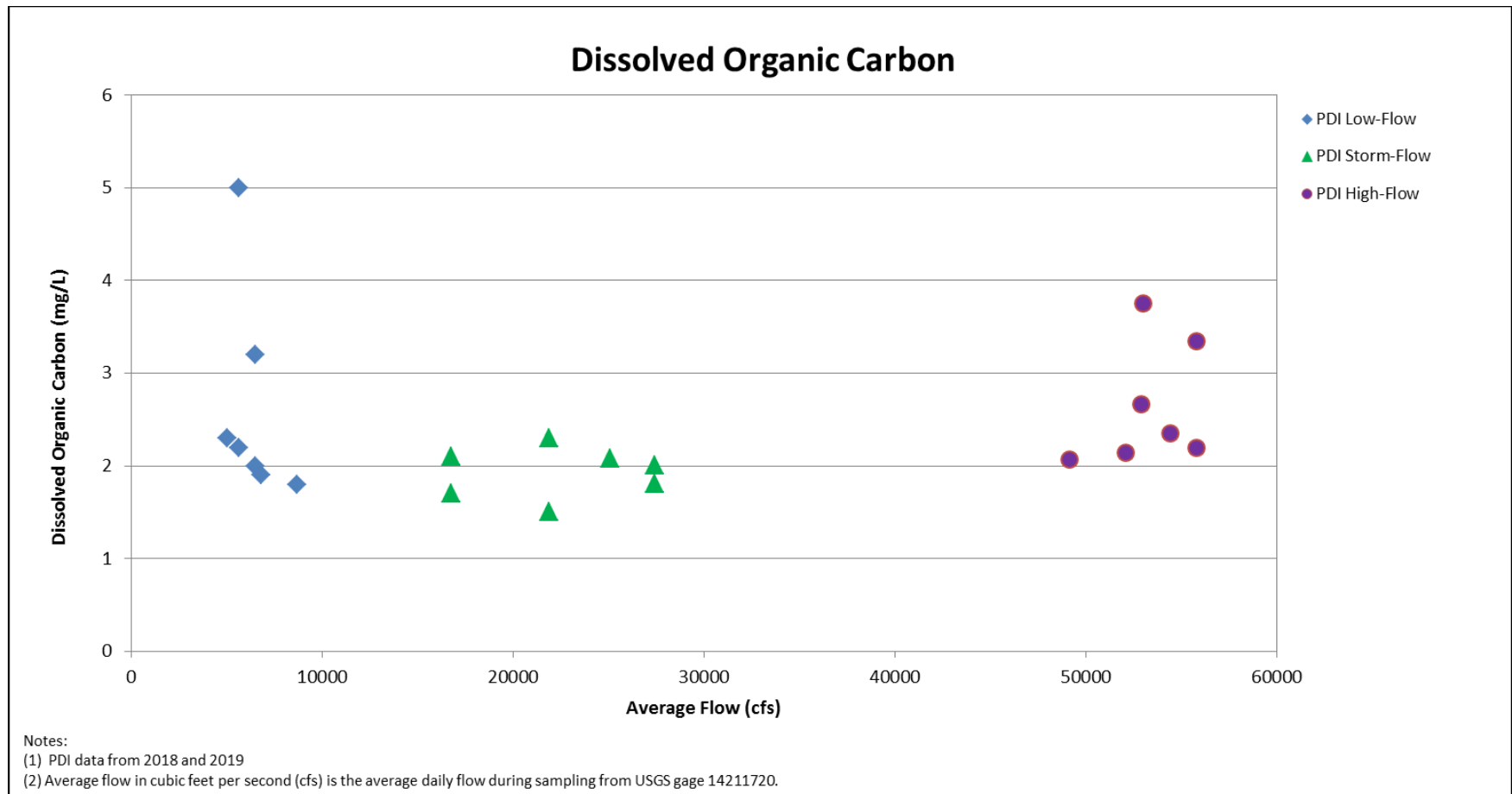Figure C-2. Concentrations of Total Suspended Solids by Discharge

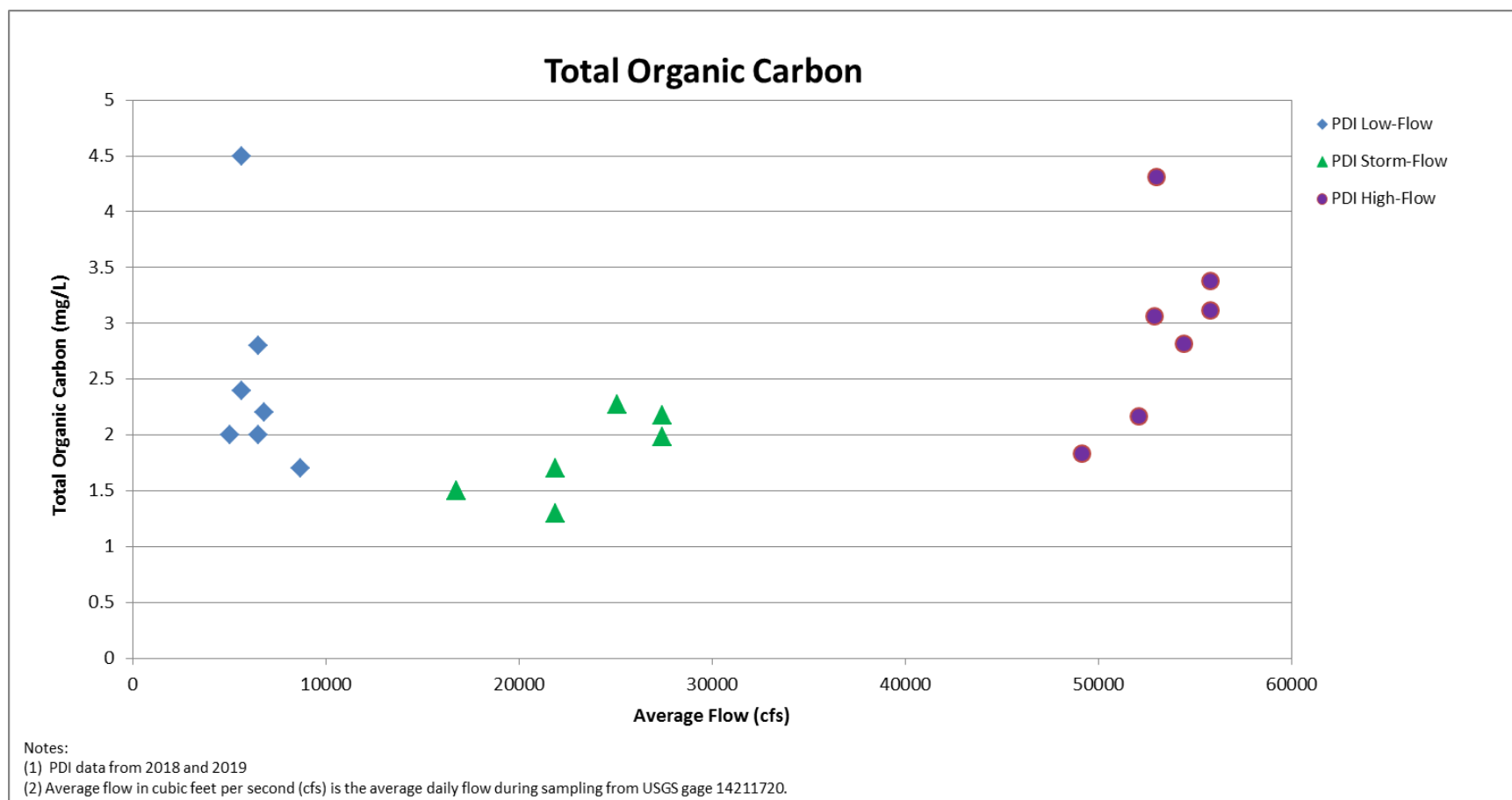Figure C-3. Concentrations of Dissolved Organic Carbon by Discharge

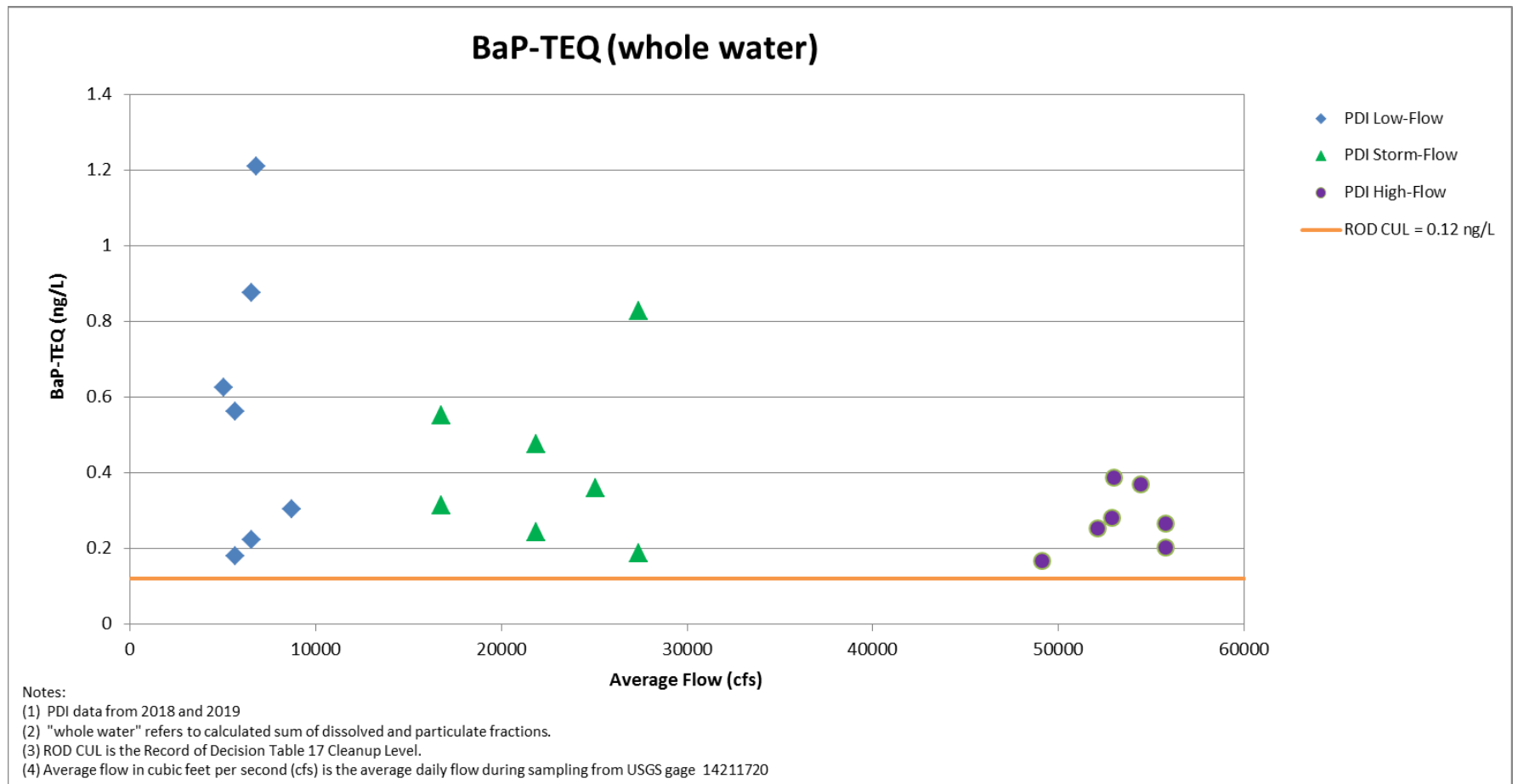Figure C-4. Concentrations of Total Organic Carbon by Discharge

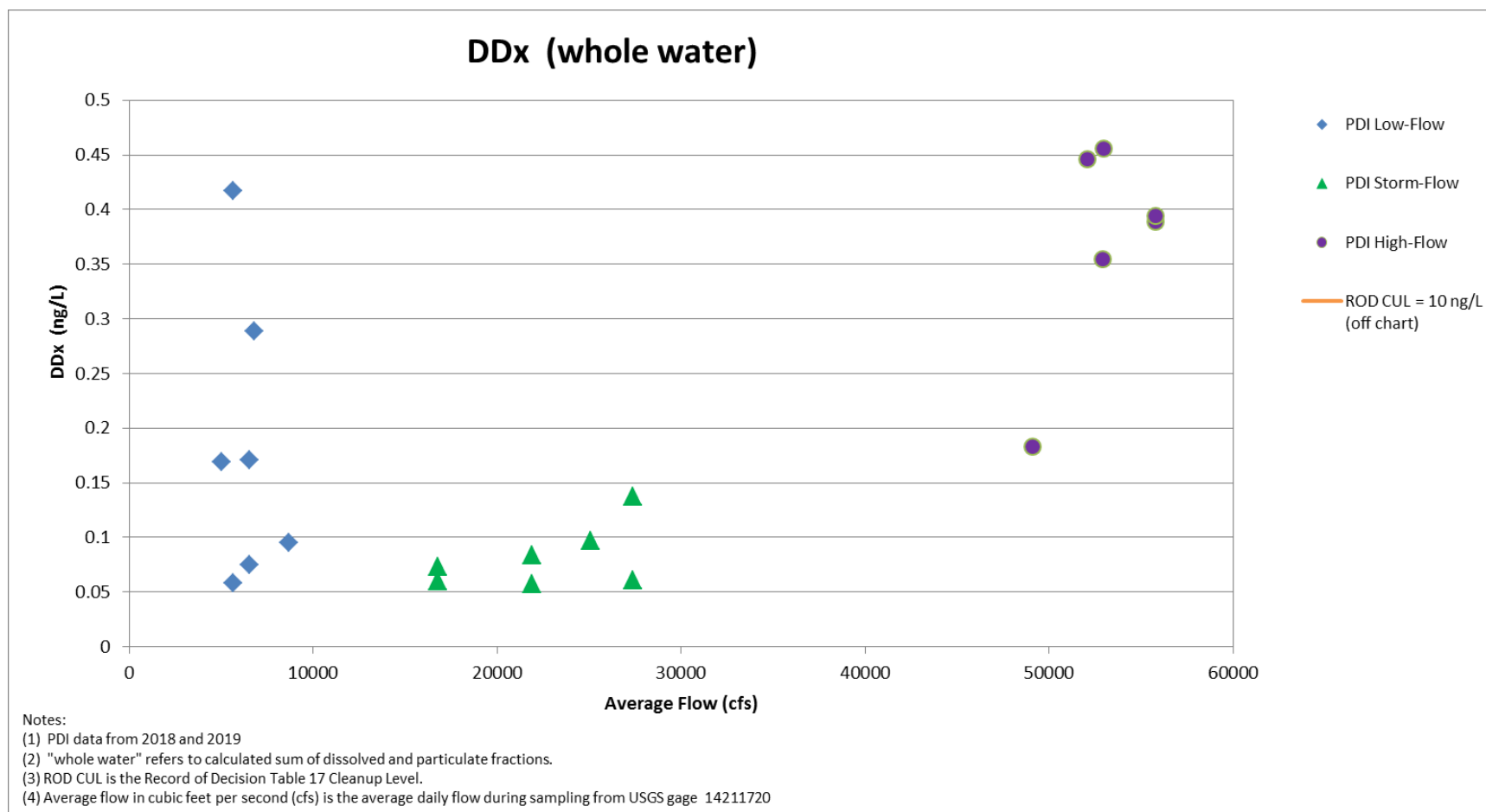Figure C-5. Concentrations of BaP-TEQ by Discharge
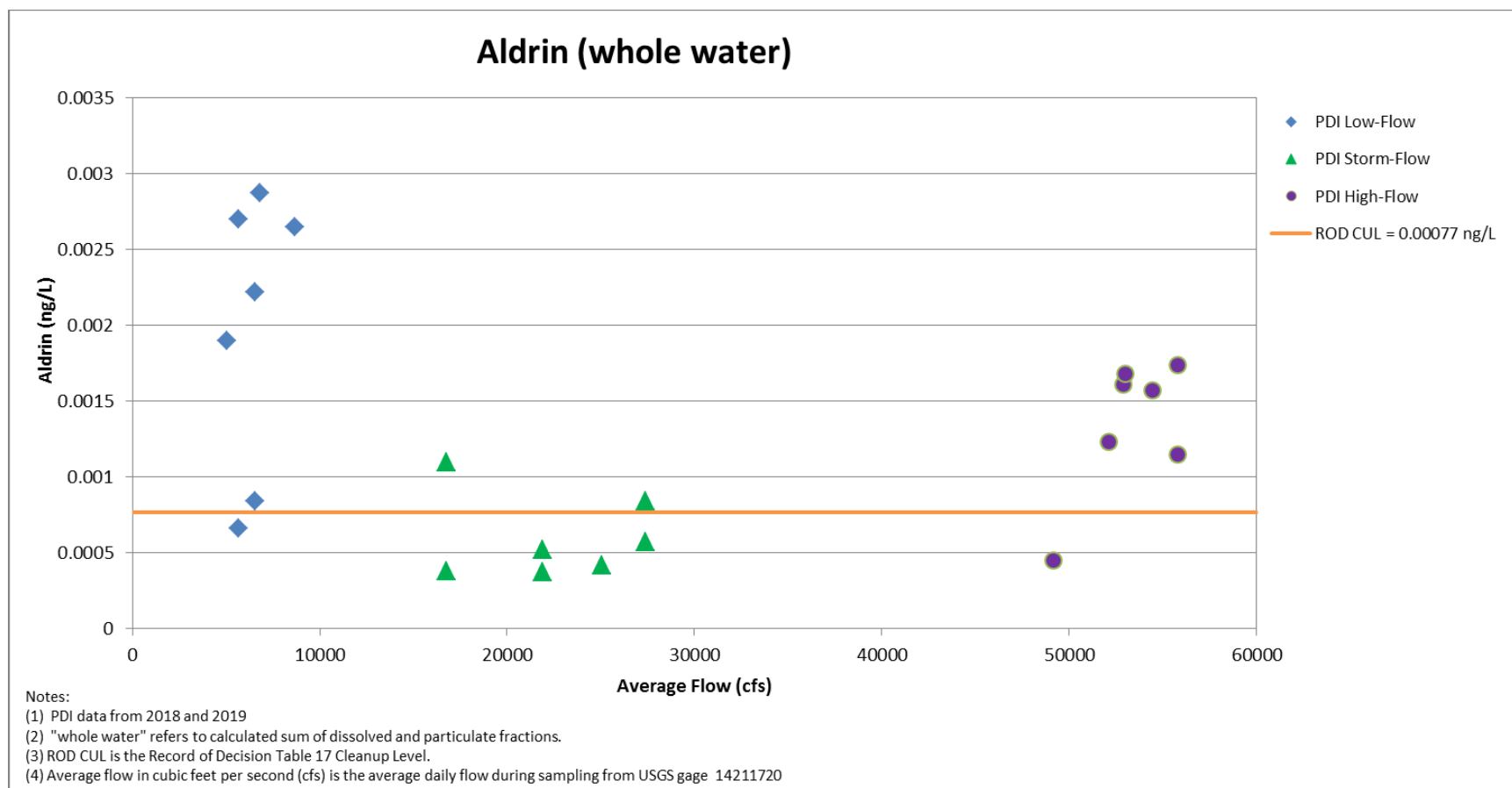
Figure C-6. DDx by Discharge

Figure C-7. Concentrations of Aldrin by Discharge

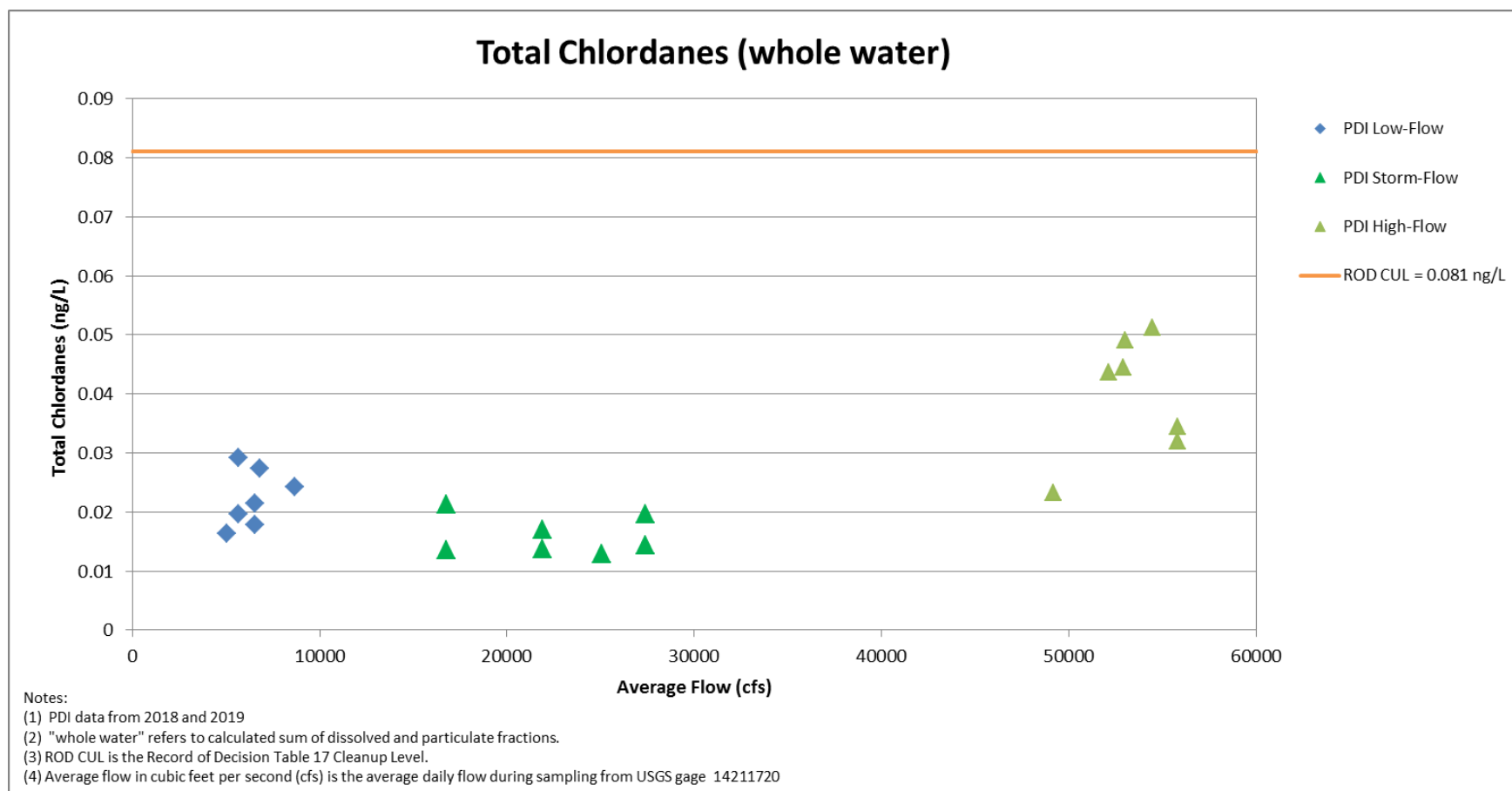Figure C-8. Concentrations of Total Chlordanes by Discharge
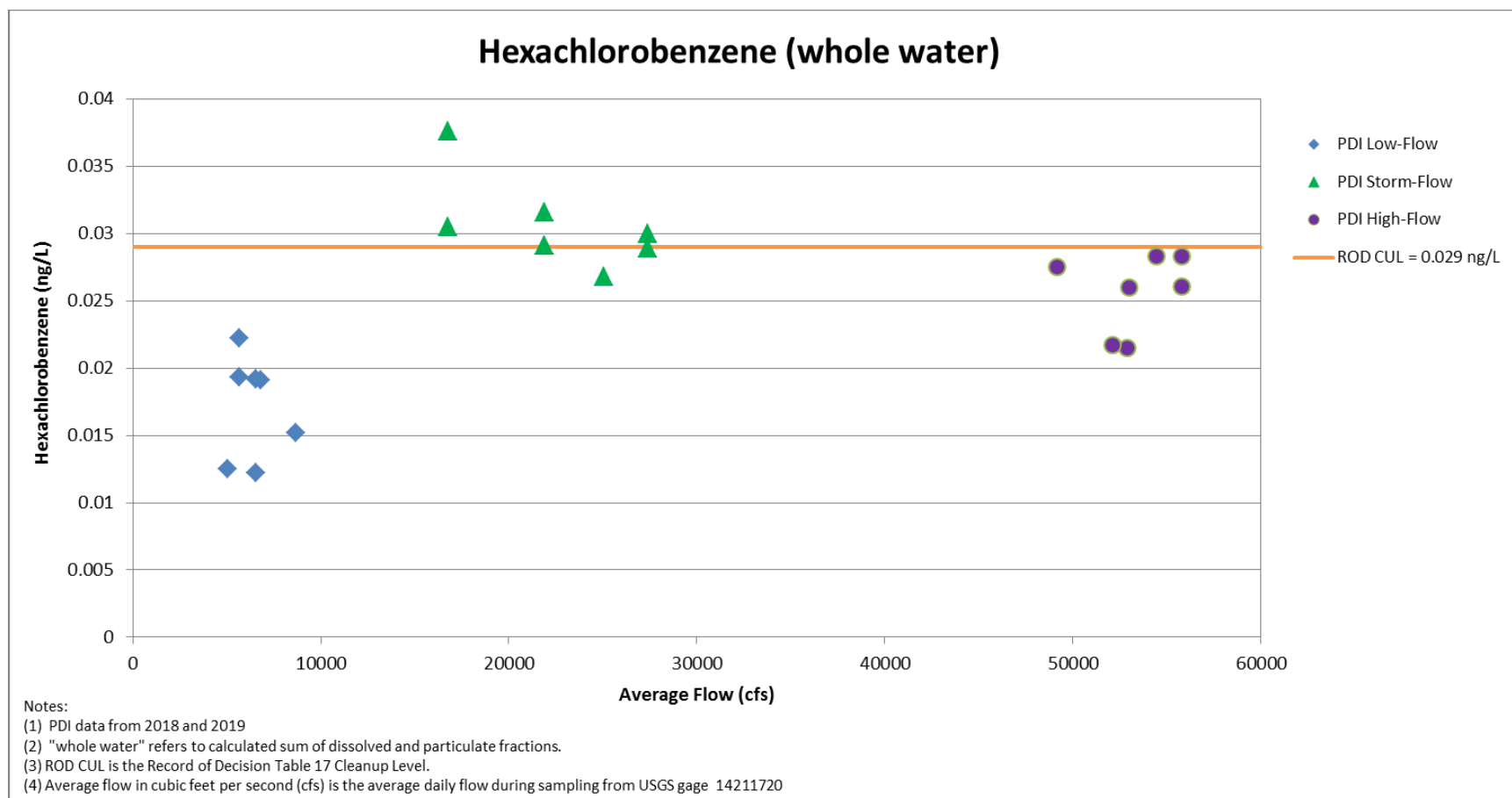
Figure C-9. Concentrations of Hexachlorobenzene by Discharge

Notes:
(1) PDI data from 2018 and 2019
(2) "whole water" refers to calculated sum of dissolved and particulate fractions.
(3) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(4) Average flow in cubic feet per second (cfs) is the average daily flow during sampling from USGS gage 14211720
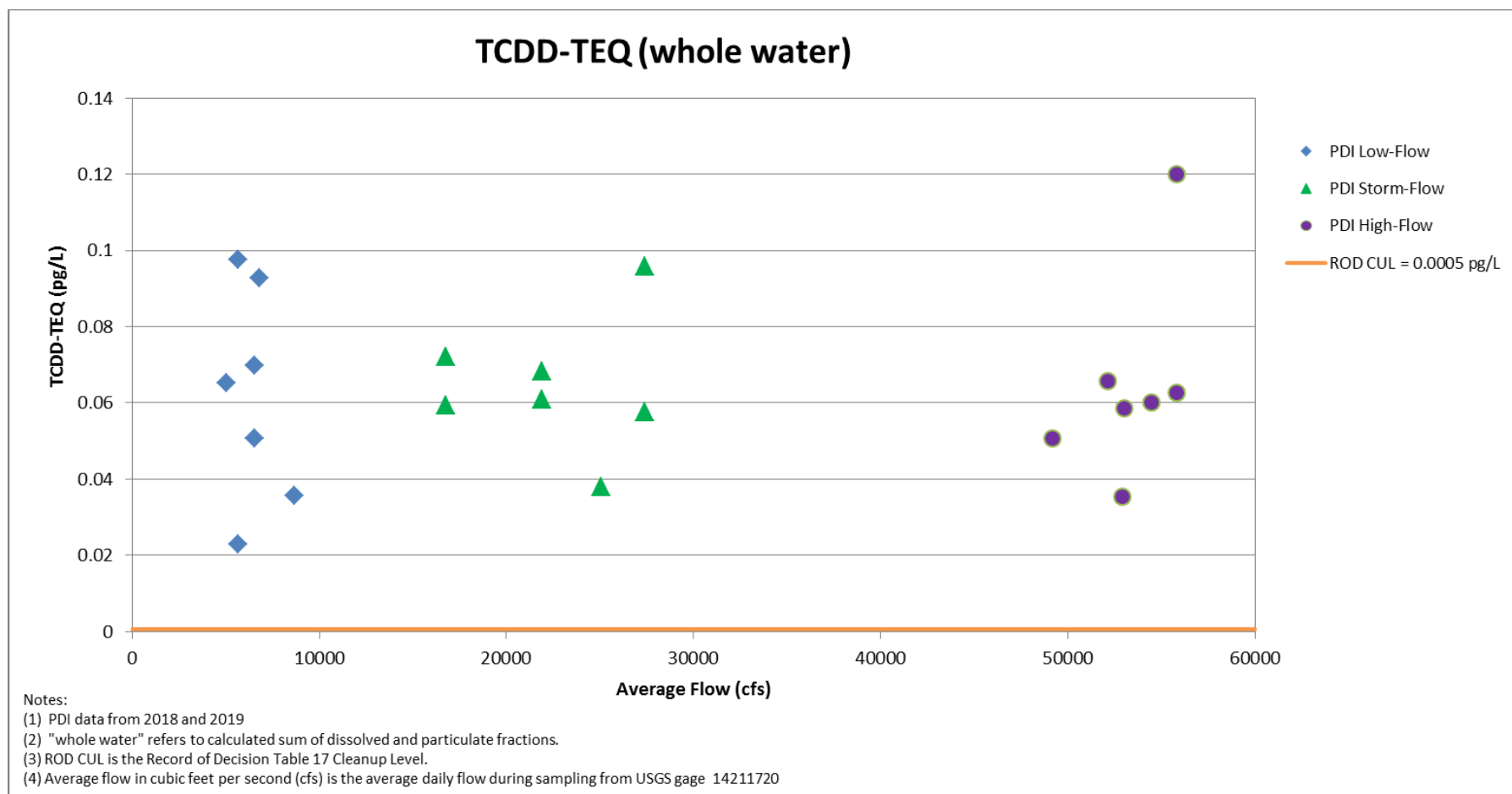
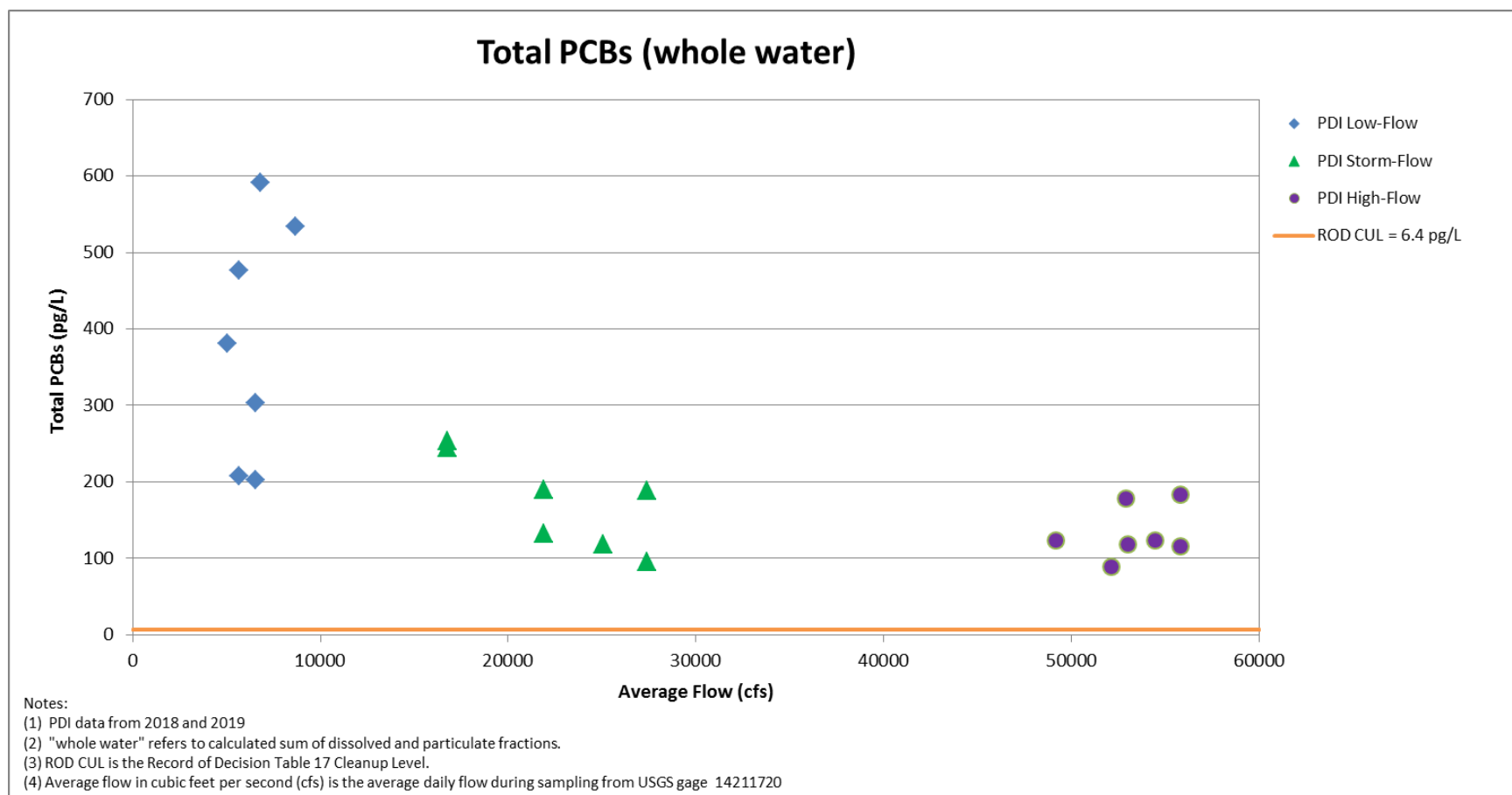Figure C-10. Concentrations of TCDD-TEQ by Discharge

Figure C-11. Concentrations of Total PCBs by Discharge

EXHIBIT D

Concentrations of COC from PDI Sampling by TSS
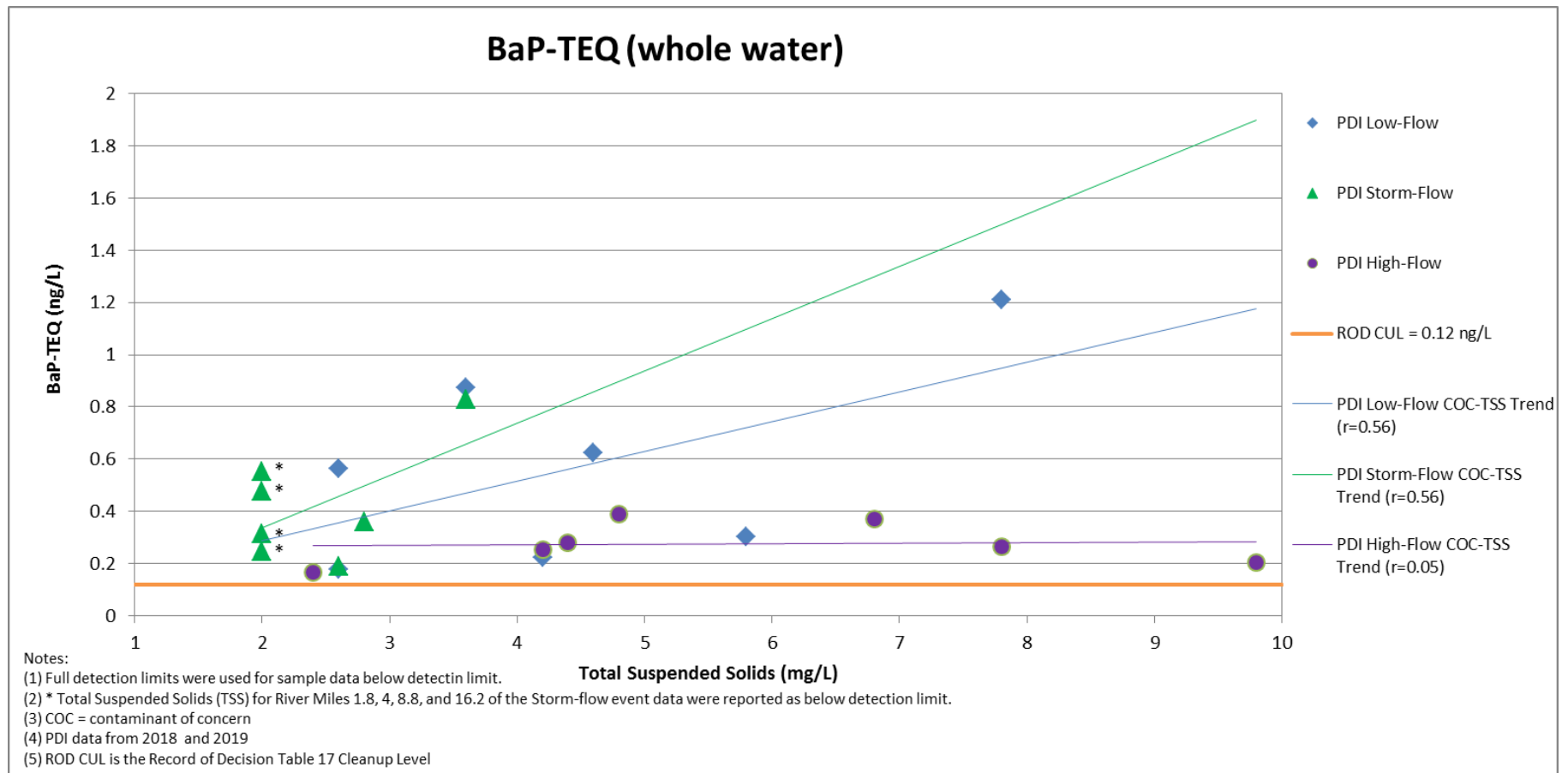
Figure D-1. Concentrations of BaP-TEQ by Total Suspended Solids (TSS)
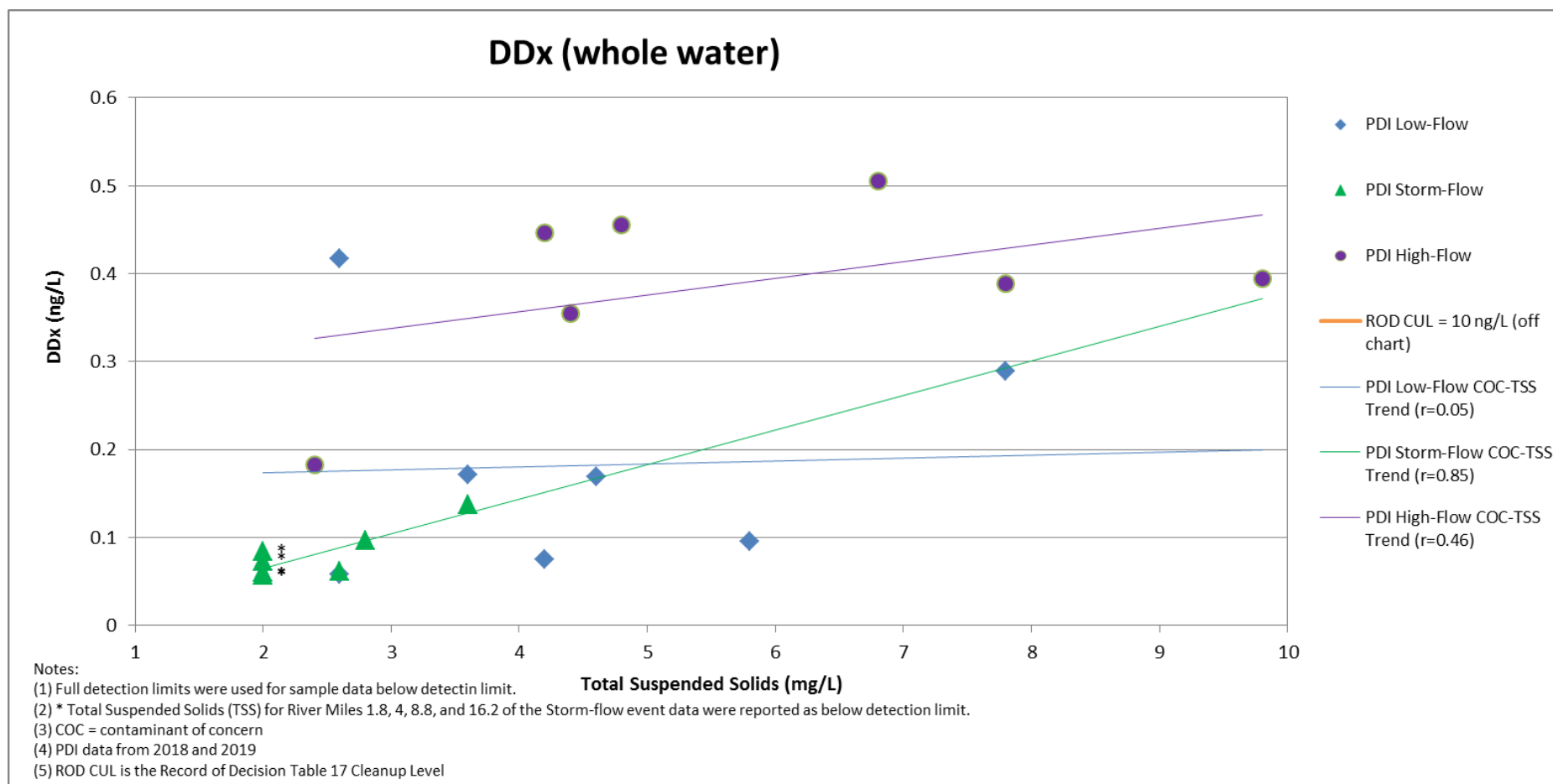
Figure D-2. Concentrations of DDx by TSS
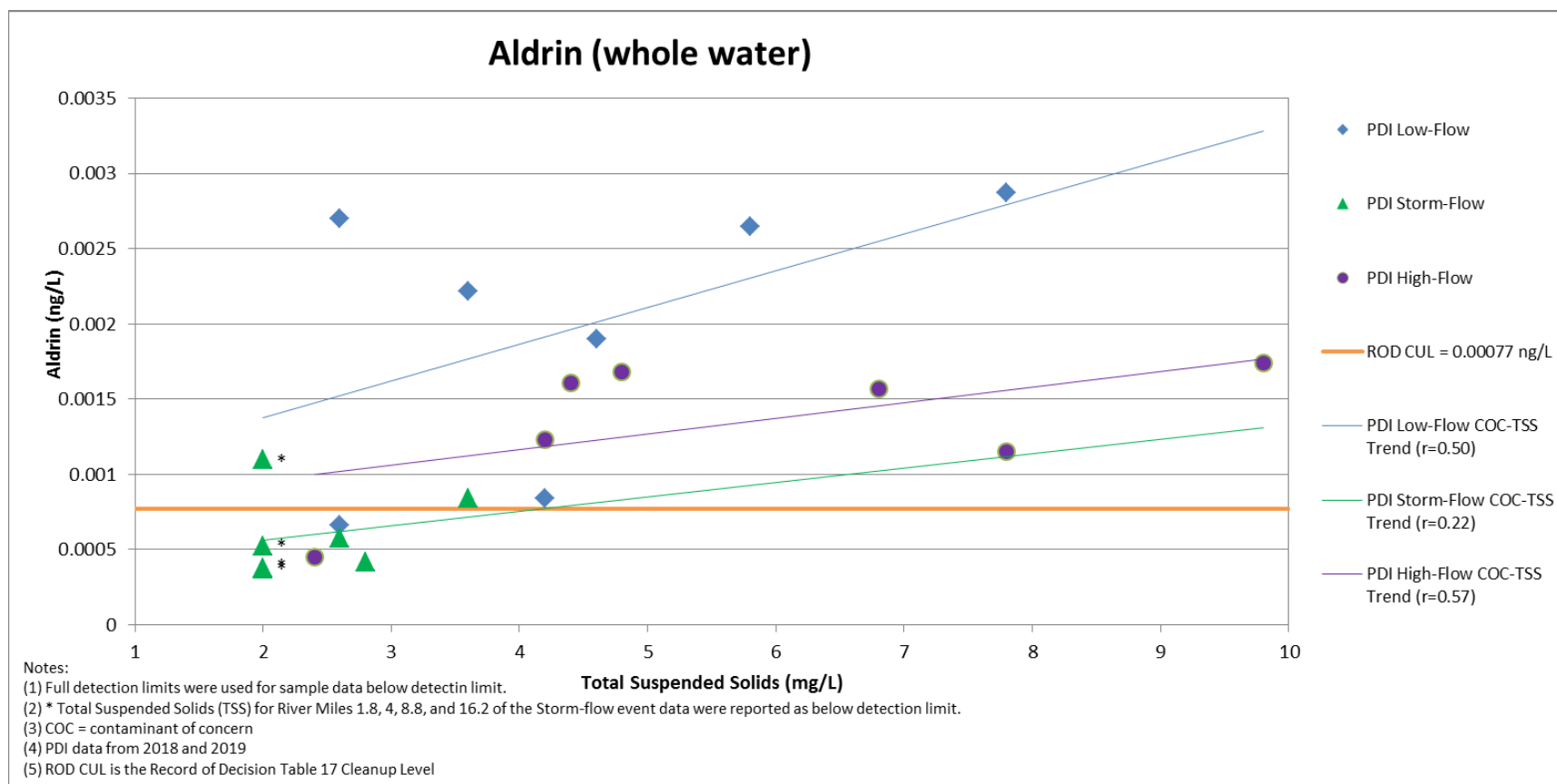
Figure D-3. Concentrations of Aldrin by TSS
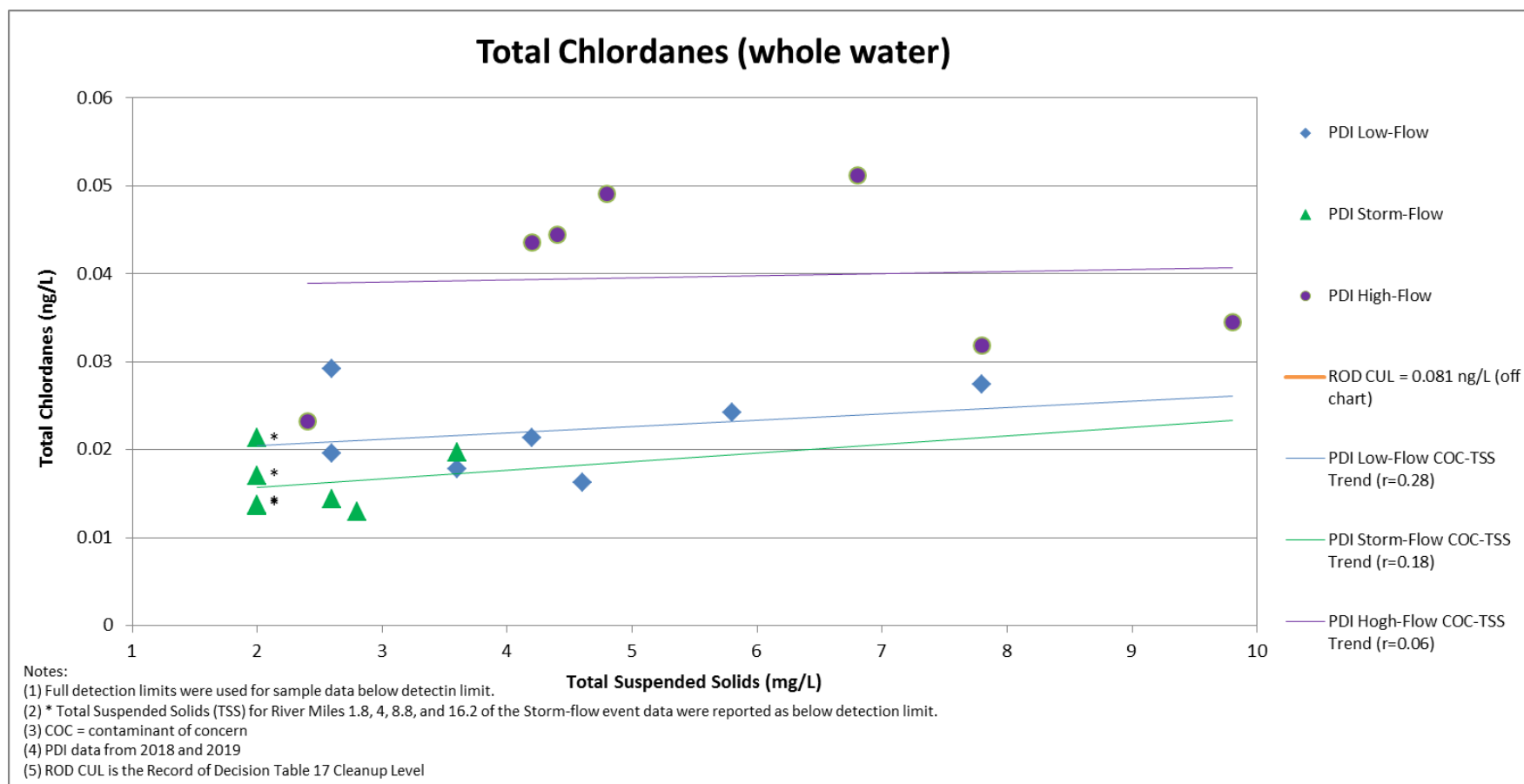
Figure D-4. Concentrations of Total Chlordanes by TSS
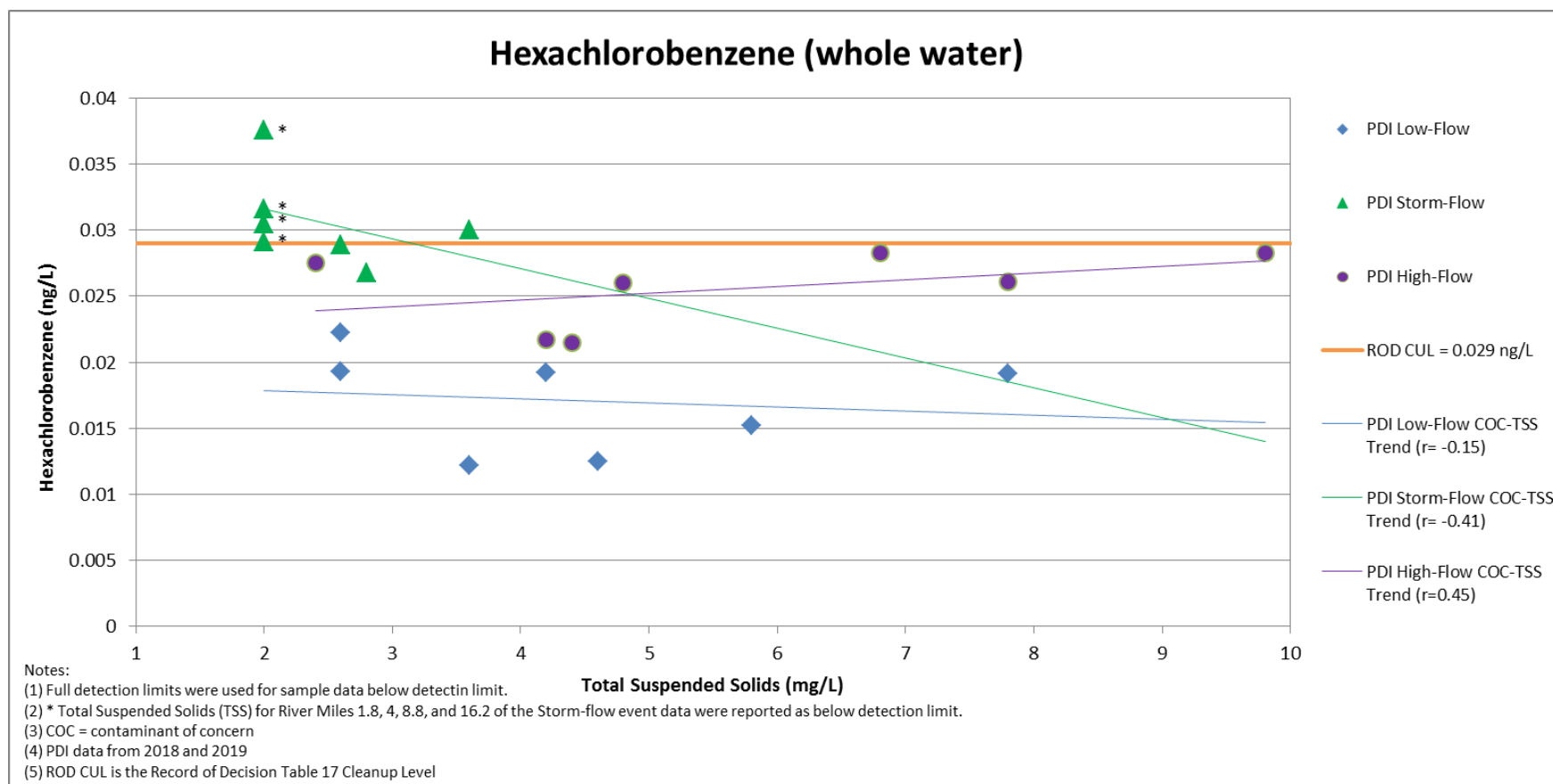
Figure D-5. Concentrations of Hexachlorobenzene by TSS

Notes:
(1) Full detection limits were used for sample data below detectin limit.
(2) * Total Suspended Solids (TSS) for River Miles 1.8, 4, 8.8, and 16.2 of the Storm-flow event data were reported as below detection limit.
(3) COC = contaminant of concern
(4) PDI data from 2018 and 2019
(5) ROD CUL is the Record of Decision Table 17 Cleanup Level
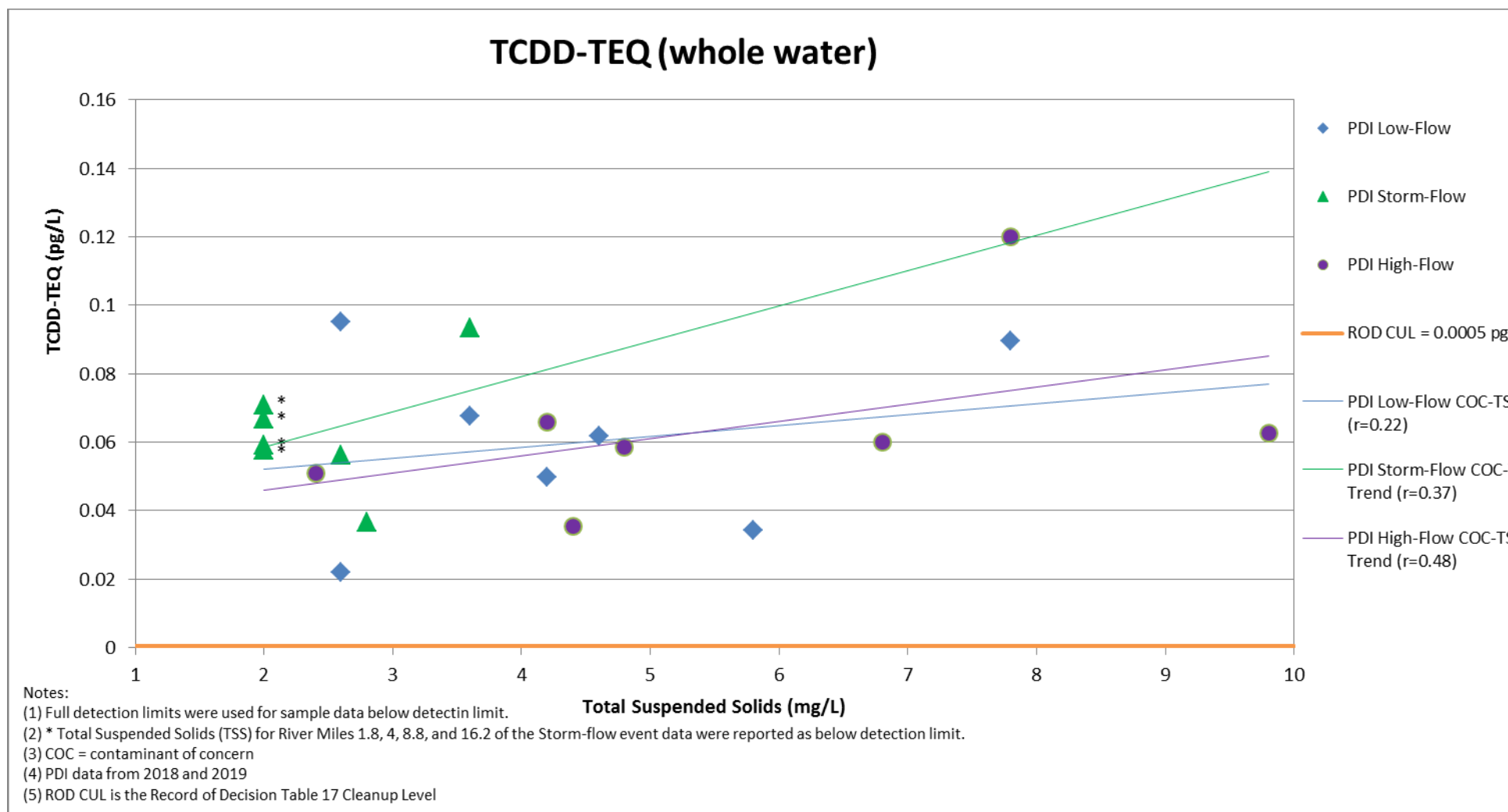
Figure D-6. Concentrations of TCDD-TEQ by TSS

Notes:
(1) Full detection limits were used for sample data below detectin limit.
(2) * Total Suspended Solids (TSS) for River Miles 1.8, 4, 8.8, and 16.2 of the Storm-flow event data were reported as below detection limit.
(3) COC = contaminant of concern
(4) PDI data from 2018 and 2019
(5) ROD CUL is the Record of Decision Table 17 Cleanup Level

Figure D-7. Concentrations of Total PCBs by TSS

EXHIBIT E

Concentrations of Dissolved, Particulate Phase, and Whole Water COCs

Figure E-1. Concentrations of Dissolved Fraction, Particulate Fraction, and Whole Water BaP-TEQ

Figure E-2. Concentrations of Dissolved Fraction, Particulate Fraction, and Whole Water DDx

Aldrin Fractions PDI Low-Flow

Notes:
(1) PDI data from 2018.
(2) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(3) Whole water refers to the calculated sum of particulate and dissolved fractions
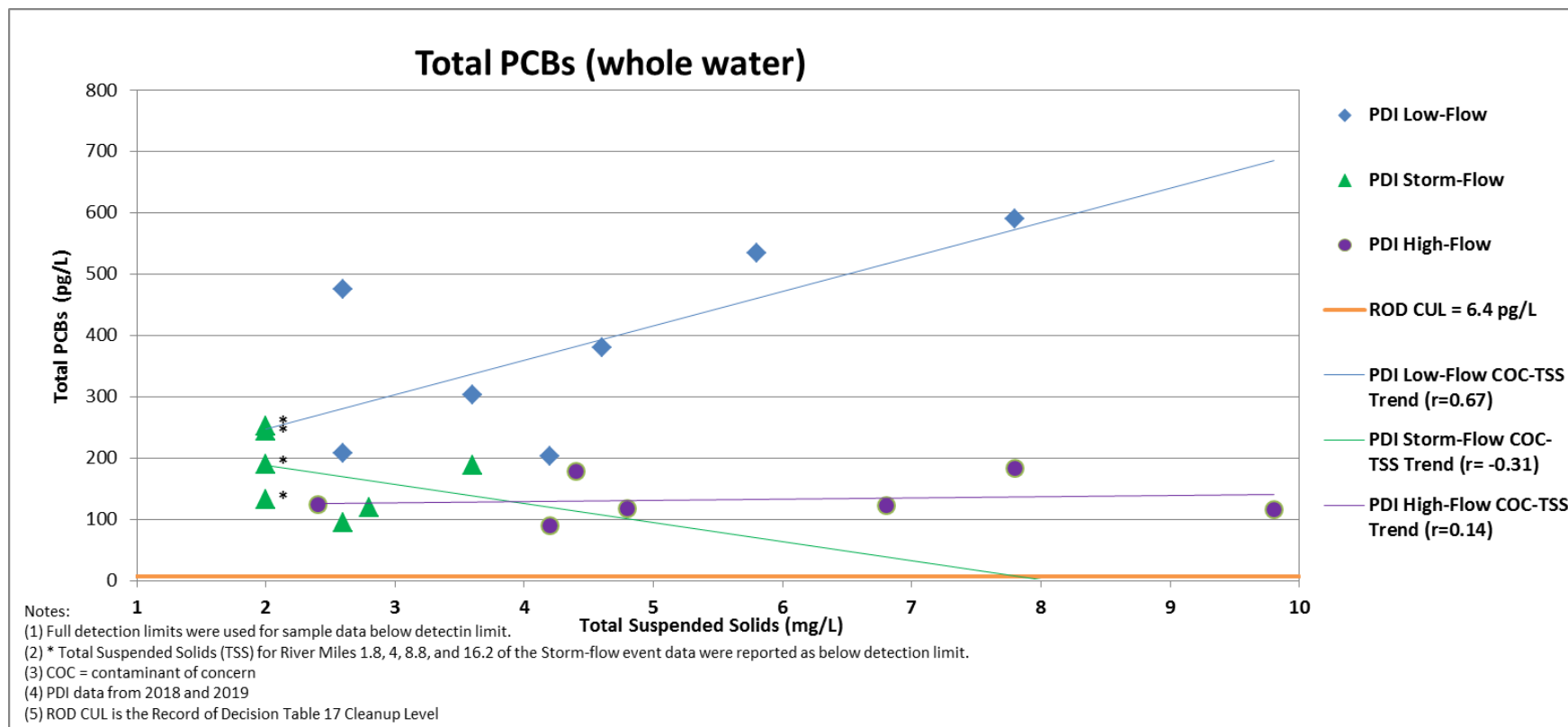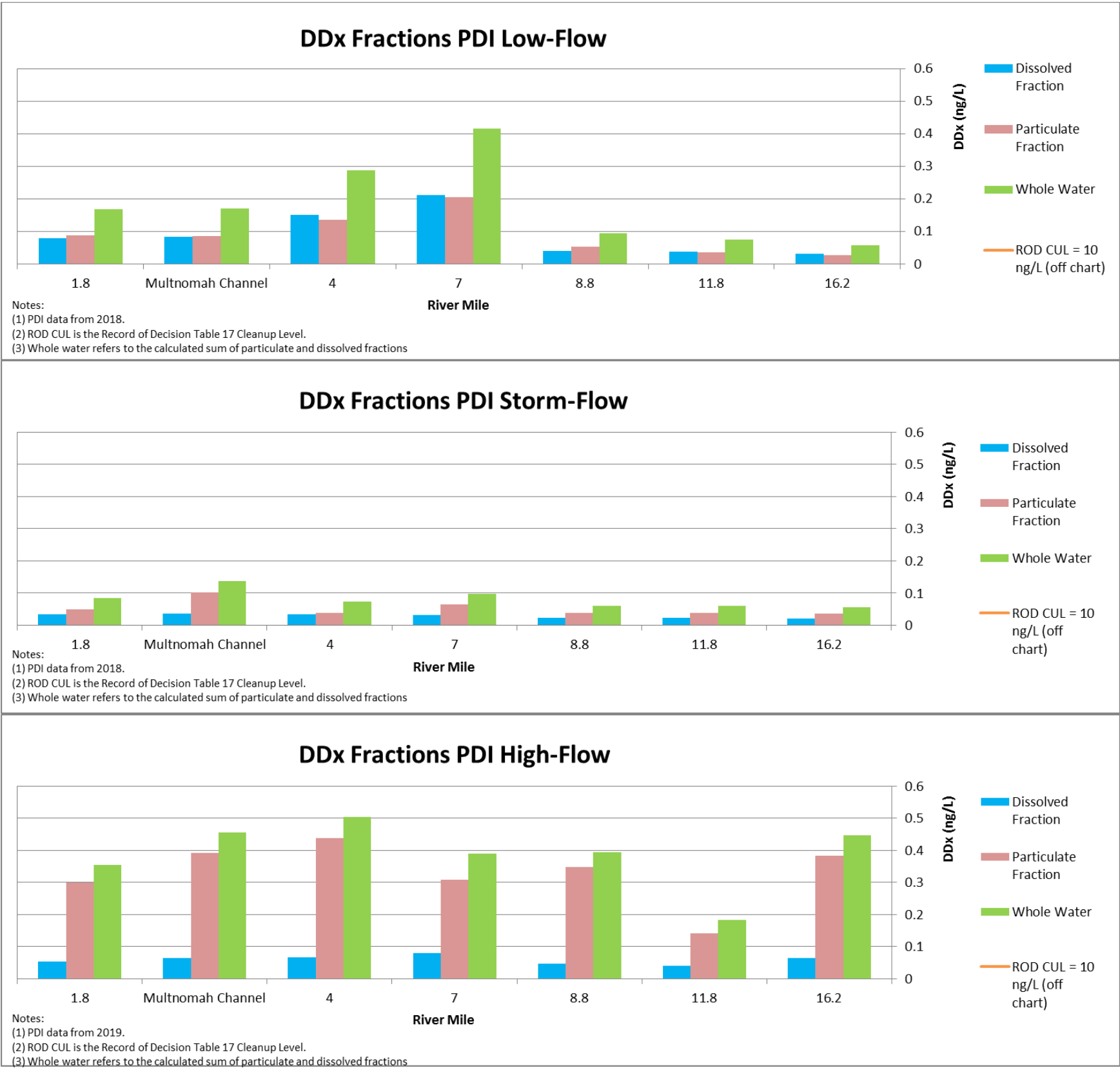(4) ND indicates data below detection limit. Full detection limits used for sample data below detection limit.

Aldrin Fractions PDI Storm-Flow

Notes:
(1) PDI data from 2018.
(2) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(3) Whole water refers to the calculated sum of particulate and dissolved fractions
(4) ND indicates data below detection limit. Full detection limits used for sample data below detection limit.

Aldrin Fractions PDI High-Flow

Notes:
(1) PDI data from 2019.
(2) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(3) Whole water refers to the calculated sum of particulate and dissolved fractions
(4) ND indicates data below detection limit. Full detection limits used for sample data below detection limit.
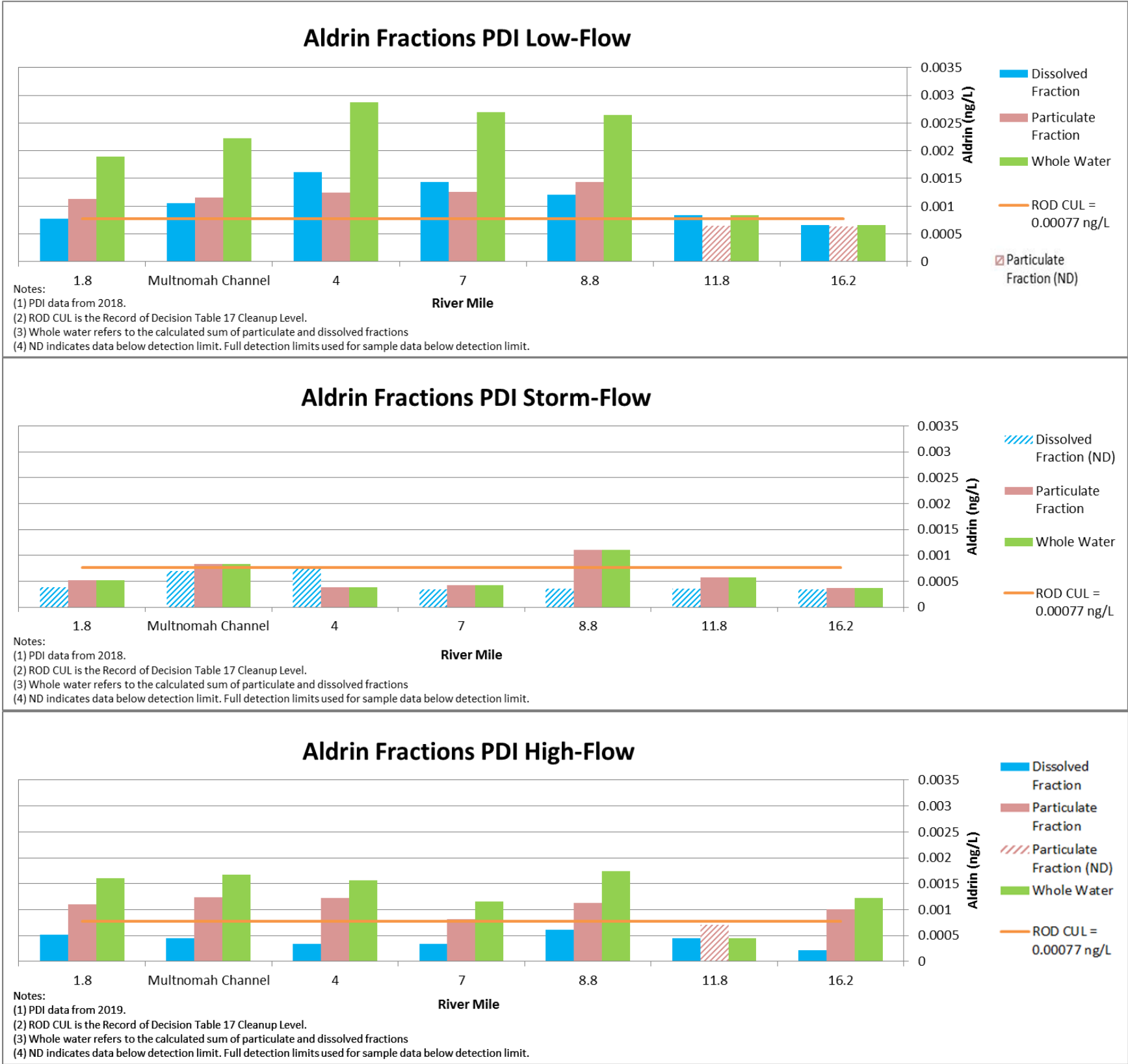
Figure E-3. Concentrations of Dissolved Fraction, Particulate Fraction, and Whole Water Aldrin
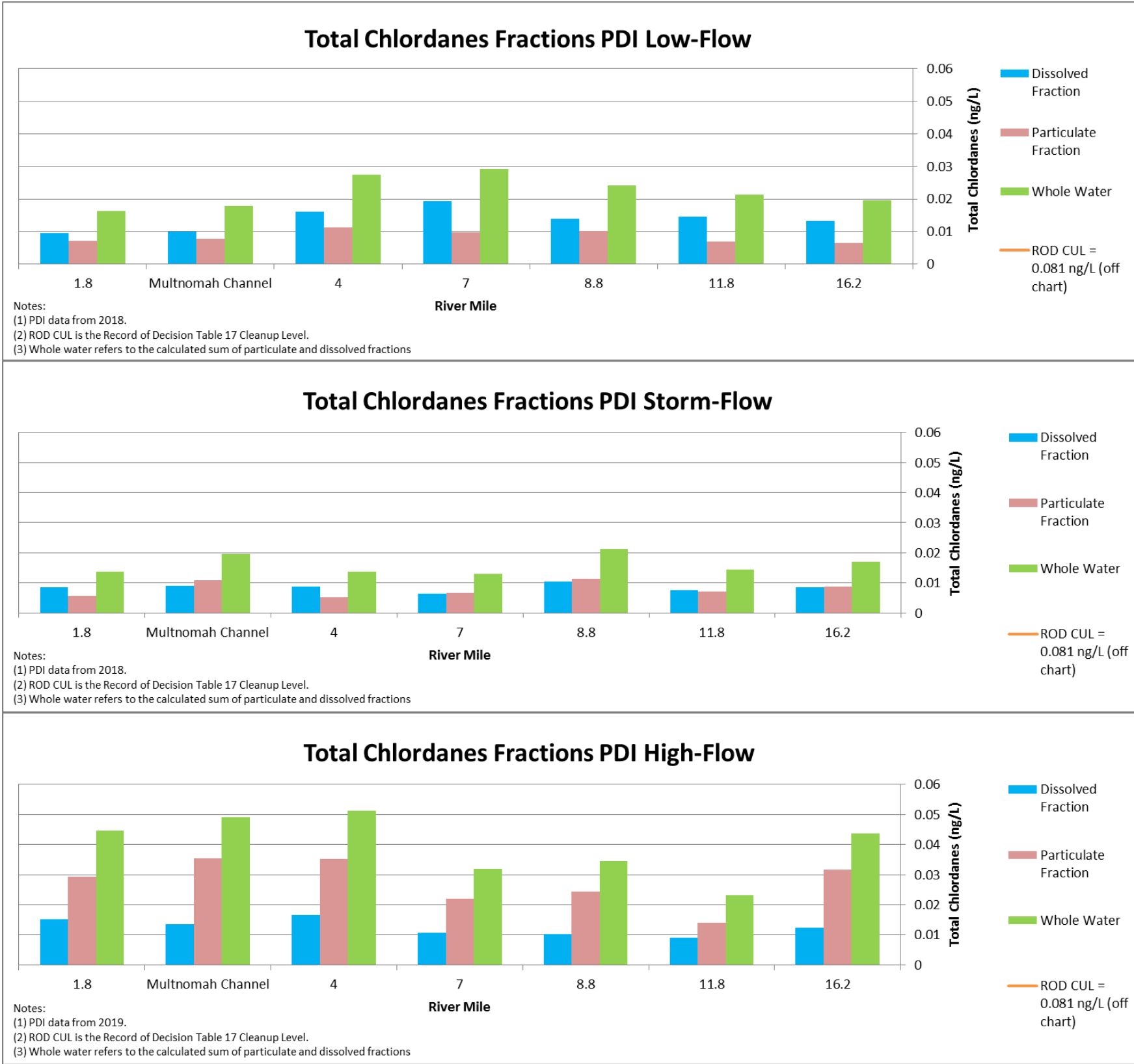
Figure E-4. Concentrations of Dissolved Fraction, Particulate Fraction, and Whole Water Total Chlordanes

Figure E-5. Concentrations of Dissolved Fraction, Particulate Fraction, and Whole Water Hexachlorobenzene

TCDD-TEQ Fractions PDI Low-Flow

Notes:
(1) PDI data from 2018.
(2) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(3) Whole water refers to the calculated sum of particulate and dissolved fractions

TCDD-TEQ Fractions PDI Storm-Flow

Notes:
(1) PDI data from 2018.
(2) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(3) Whole water refers to the calculated sum of particulate and dissolved fractions

TCDD-TEQ Fractions PDI High-Flow

Notes:
(1) PDI data from 2019.
(2) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(3) Whole water refers to the calculated sum of particulate and dissolved fractions

Figure E-6. Concentrations of Dissolved Fraction, Particulate Fraction, and Whole Water TCDD-TEQ
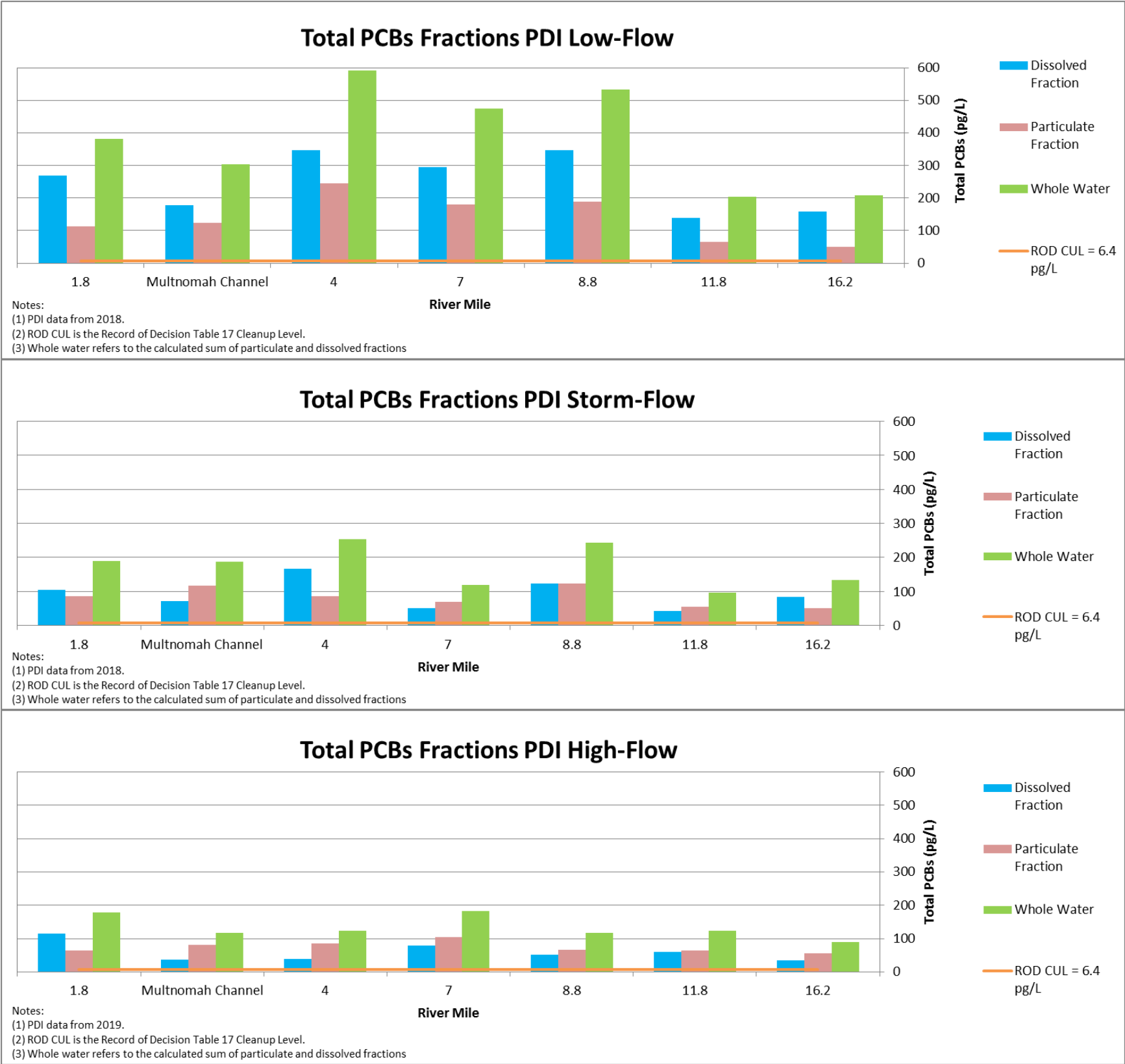
Figure E-7. Concentrations of Dissolved Fraction, Particulate Fraction, and Whole Water Total PCBs

EXHIBIT F

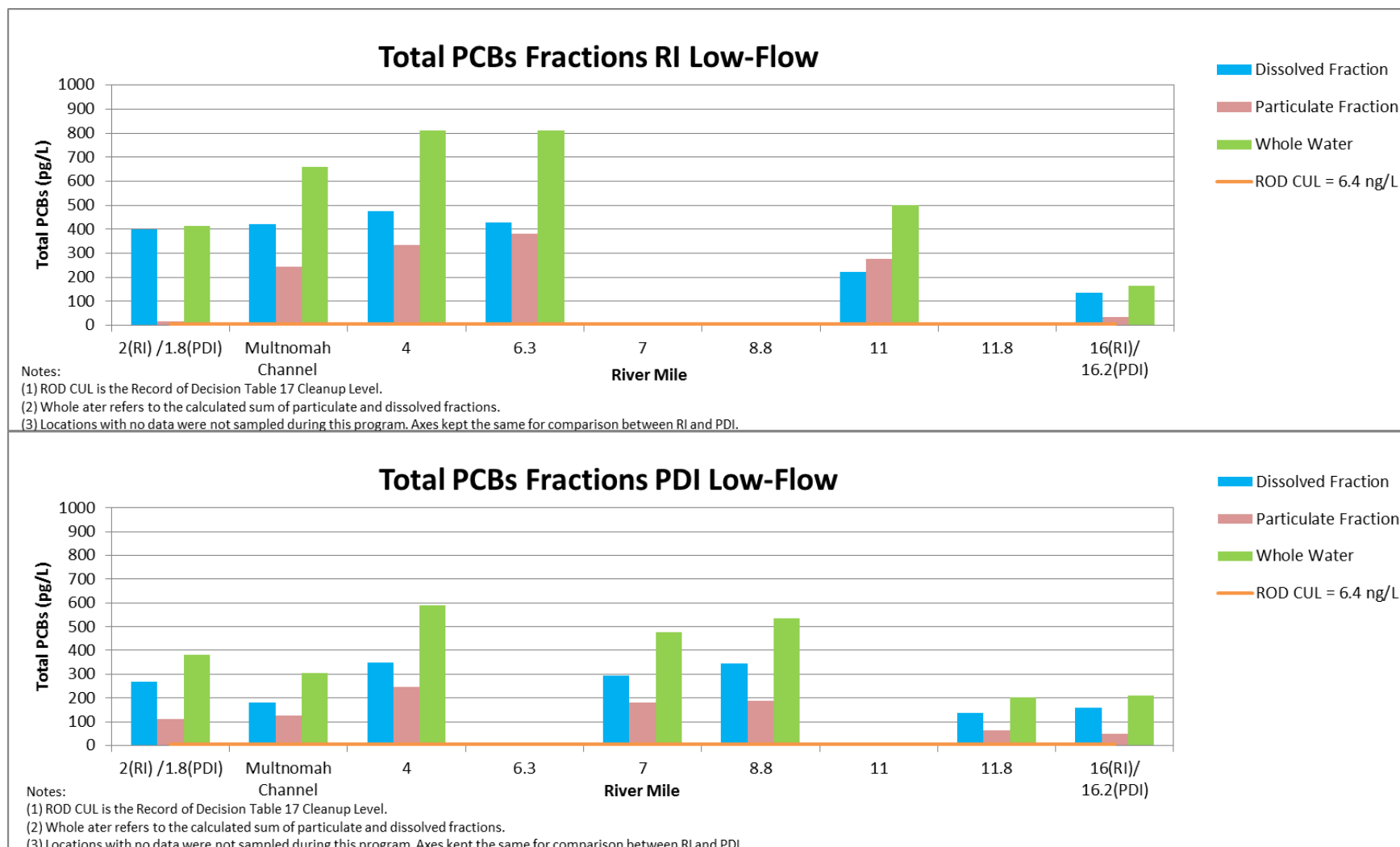Figures Comparing COC Concentrations in Low-Flow Events 2006 vs. 2018

Total PCBs Fractions RI Low-Flow

Legend:
- Dissolved Fraction
- Particulate Fraction
- Whole Water
- ROD CUL = 6.4 ng/L

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.

Total PCBs Fractions PDI Low-Flow

Legend:
- Dissolved Fraction
- Particulate Fraction
- Whole Water
- ROD CUL = 6.4 ng/L

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.

Figure F-1. Comparison of Fractions in Low-Flow Events 2006 (RI) vs. 2018 (PDI): Total PCBs

DDx Fractions RI Low-Flow

Legend:
- Dissolved Fraction
- Particulate Fraction
- Whole Water
- ROD CUL = 10 ng/L (off chart)

Y-axis: DDx (ng/L)
X-axis: River Mile — 2(RI) /1.8(PDI), Multnomah Channel, 4, 6.3, 7, 8.8, 11, 11.8, 16(RI)/16.2(PDI)

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.

DDx Fractions PDI Low-Flow

Legend:
- Dissolved Fraction
- Particulate Fraction
- Whole Water
- ROD CUL = 10 ng/L (off chart)

Y-axis: DDx (ng/L)
X-axis: River Mile — 2(RI) /1.8(PDI), Multnomah Channel, 4, 6.3, 7, 8.8, 11, 11.8, 16(RI)/16.2(PDI)

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.

Figure F-2. Comparison of Fractions in Low-Flow Events 2006 (RI) vs. 2018 (PDI): DDx
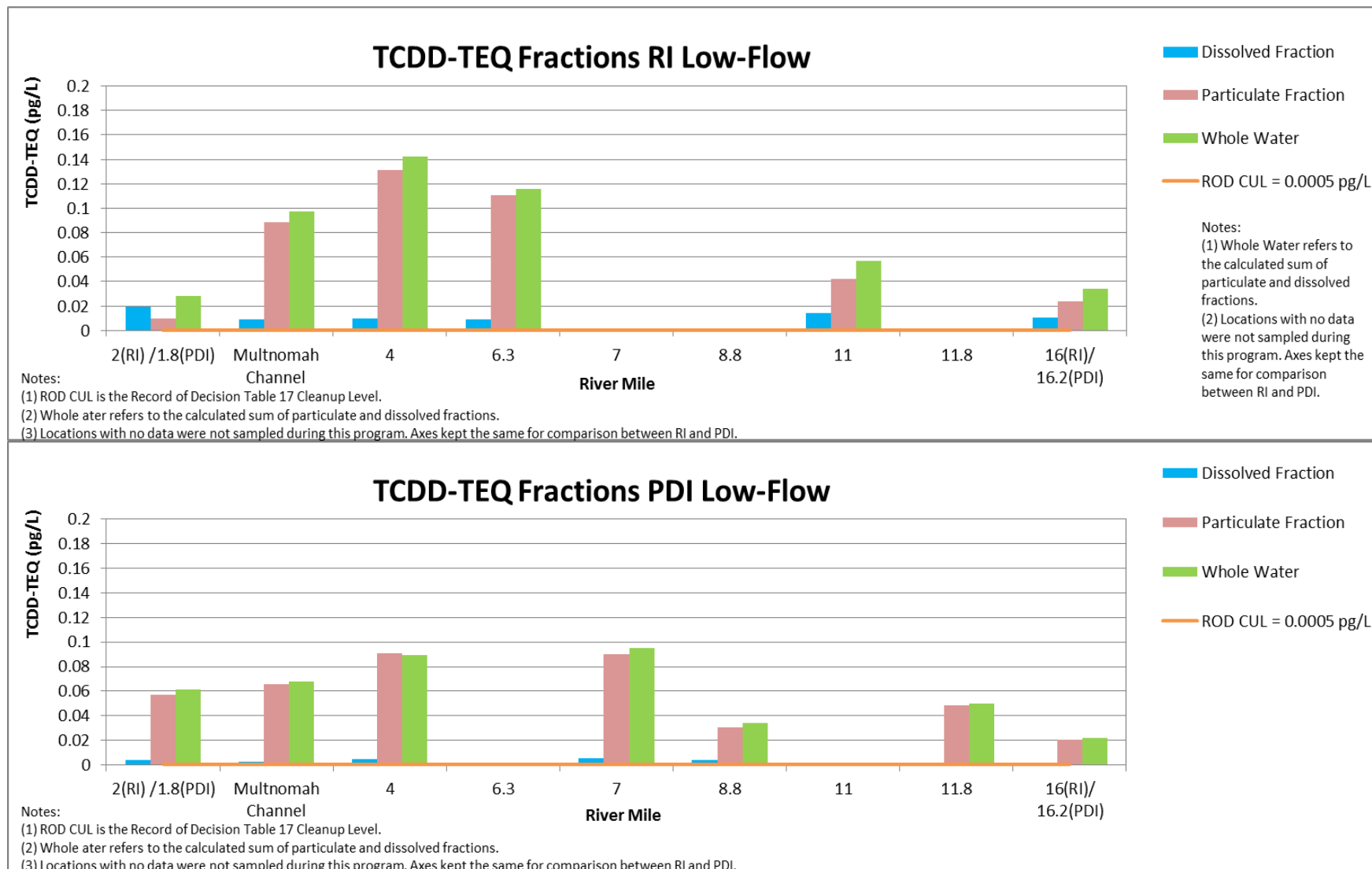
Figure F-3. Comparison of Fractions in Low-Flow Events 2006 (RI) vs. 2018 (PDI): TCDD-TEQ
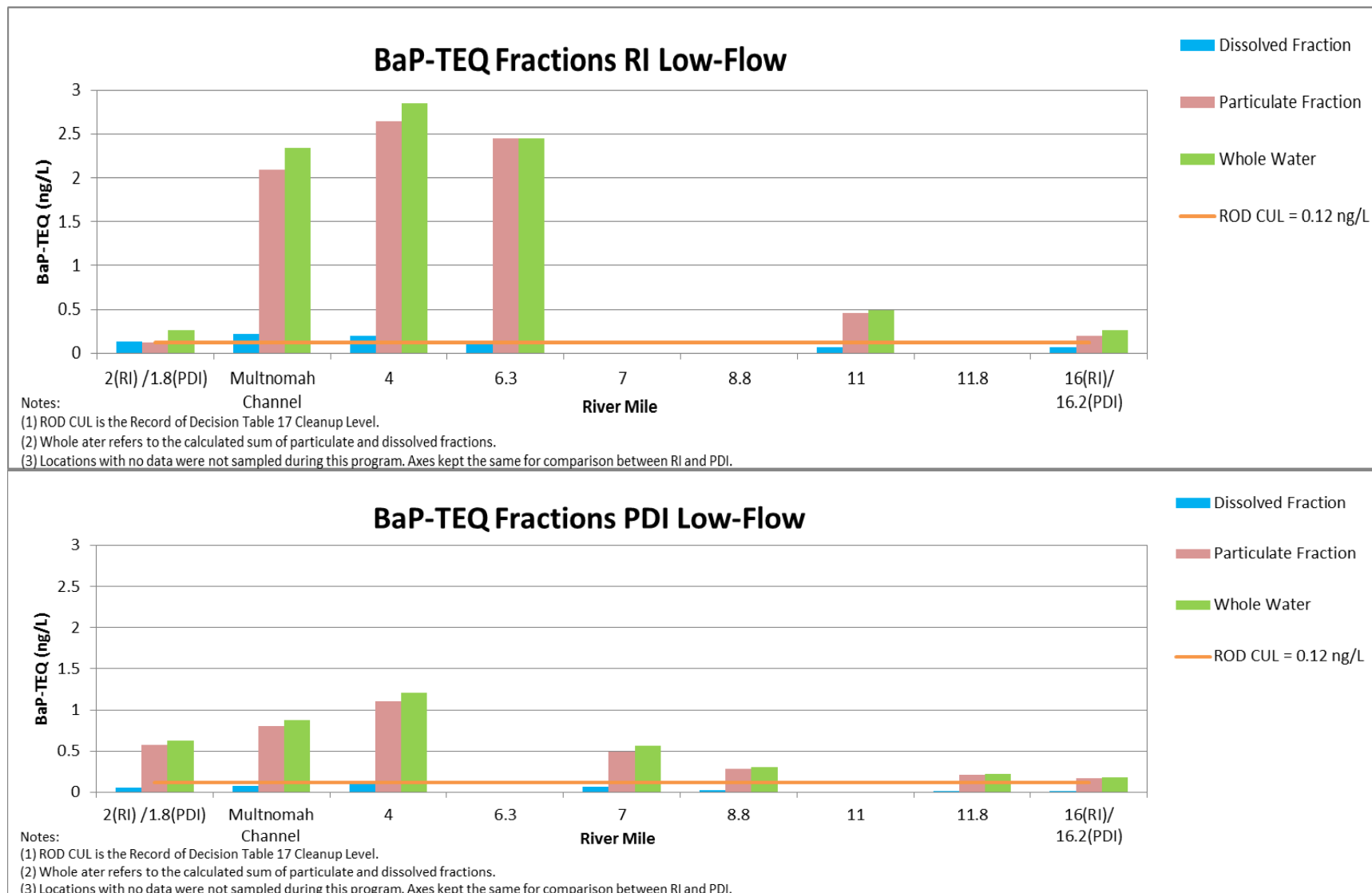
Figure F-4. Comparison of Fractions in Low-Flow Events 2006 (RI) vs. 2018 (PDI): BaP-TEQ
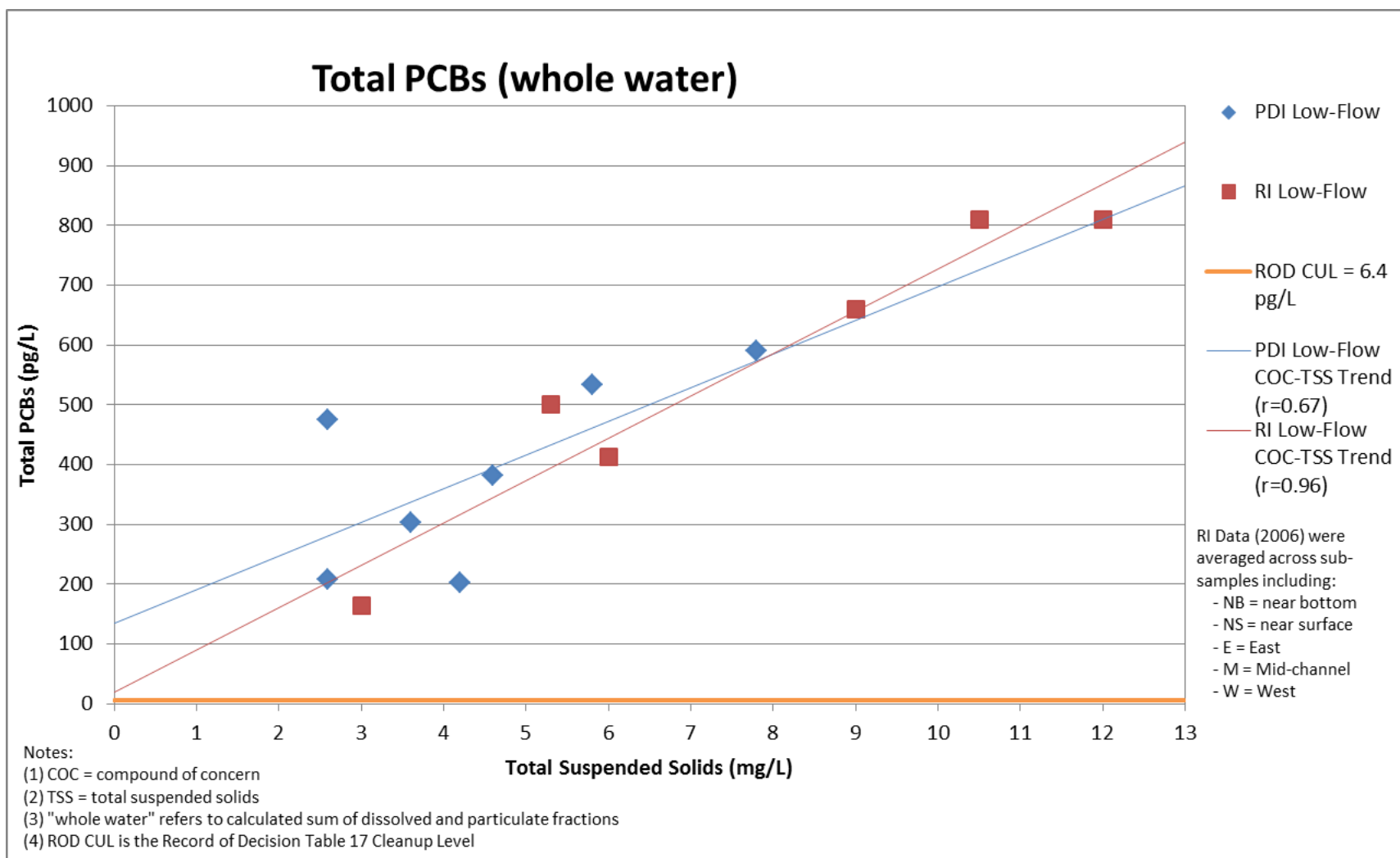
Figure F-5. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI): Total PCBs vs. Total Suspended Solids
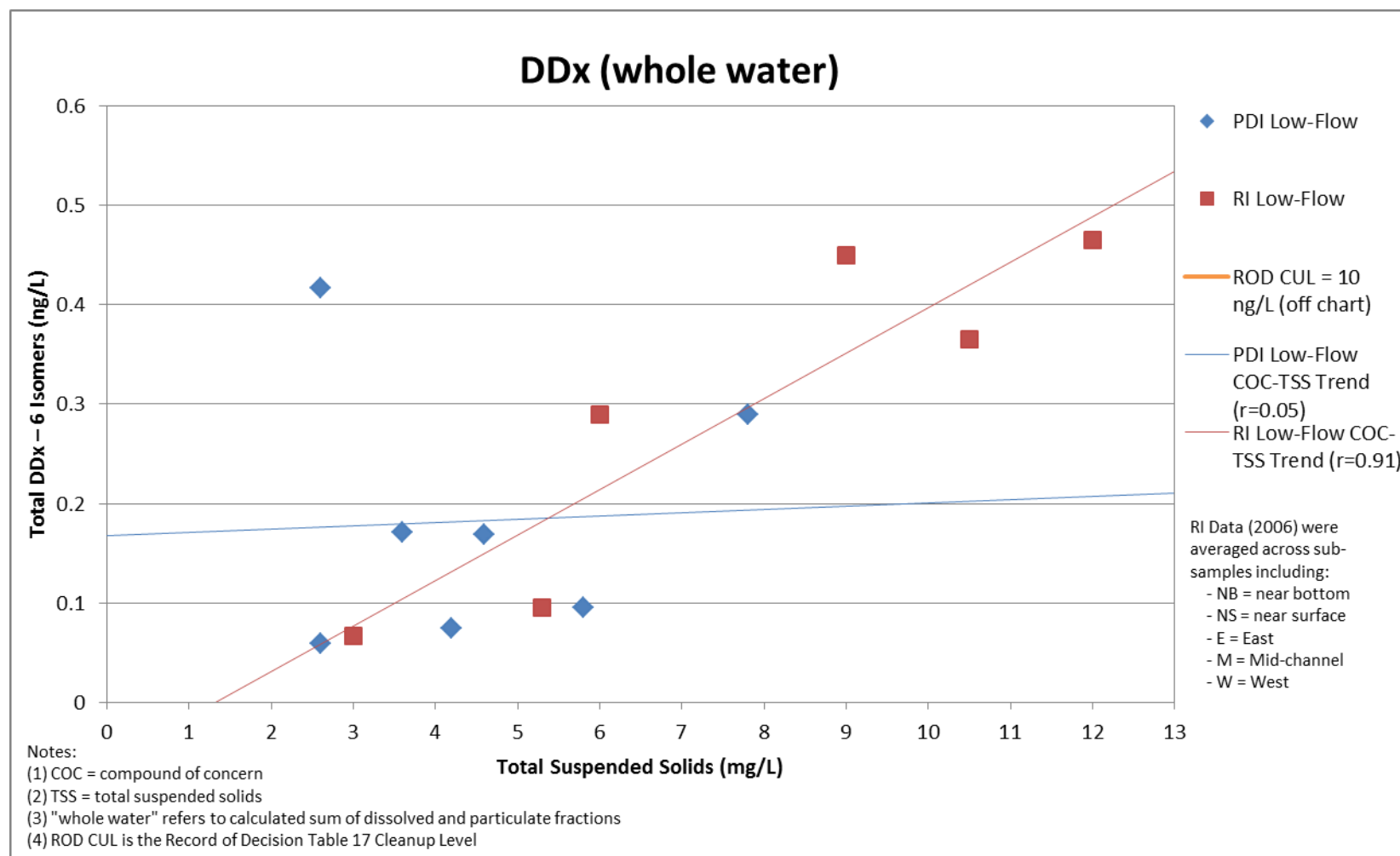
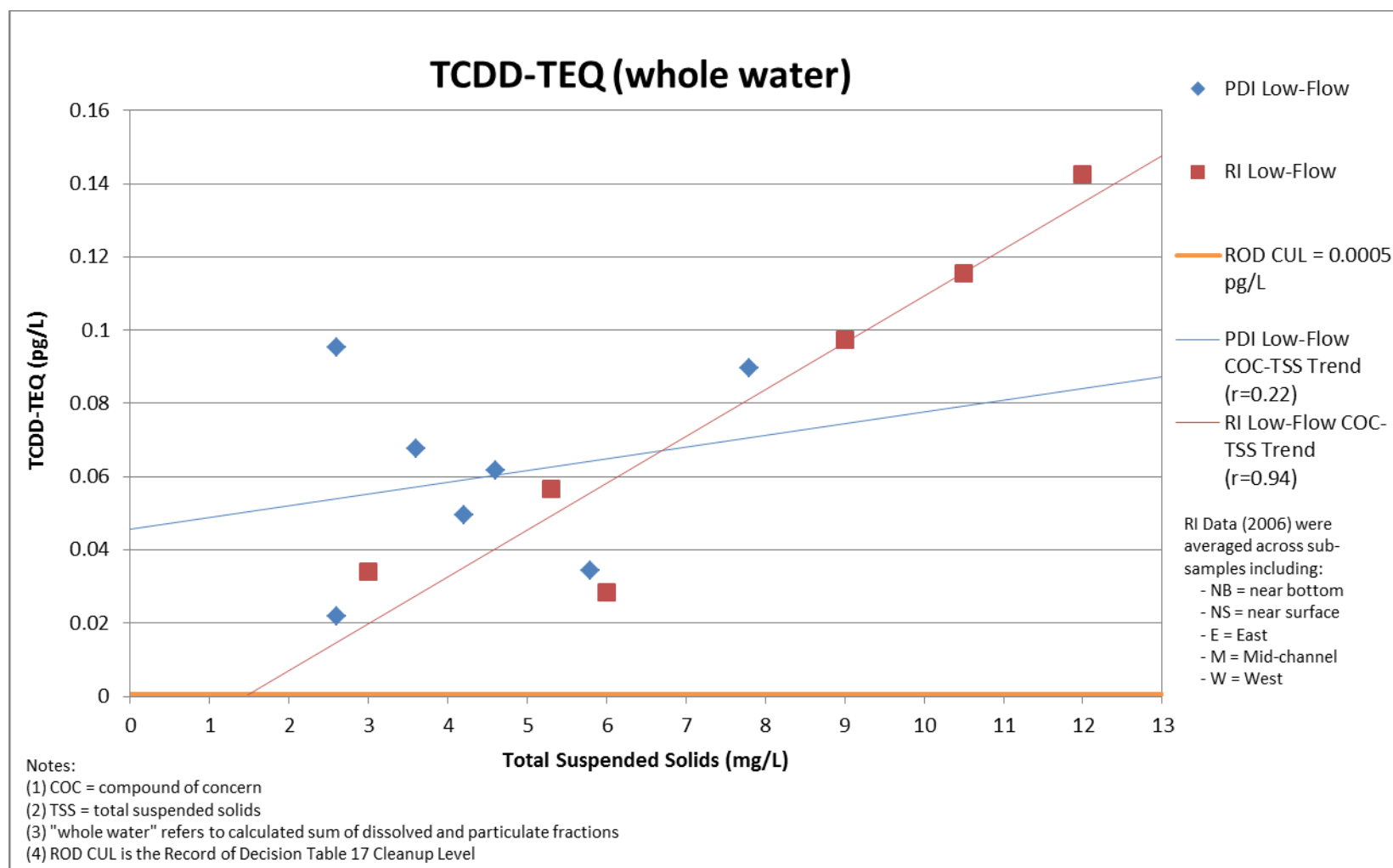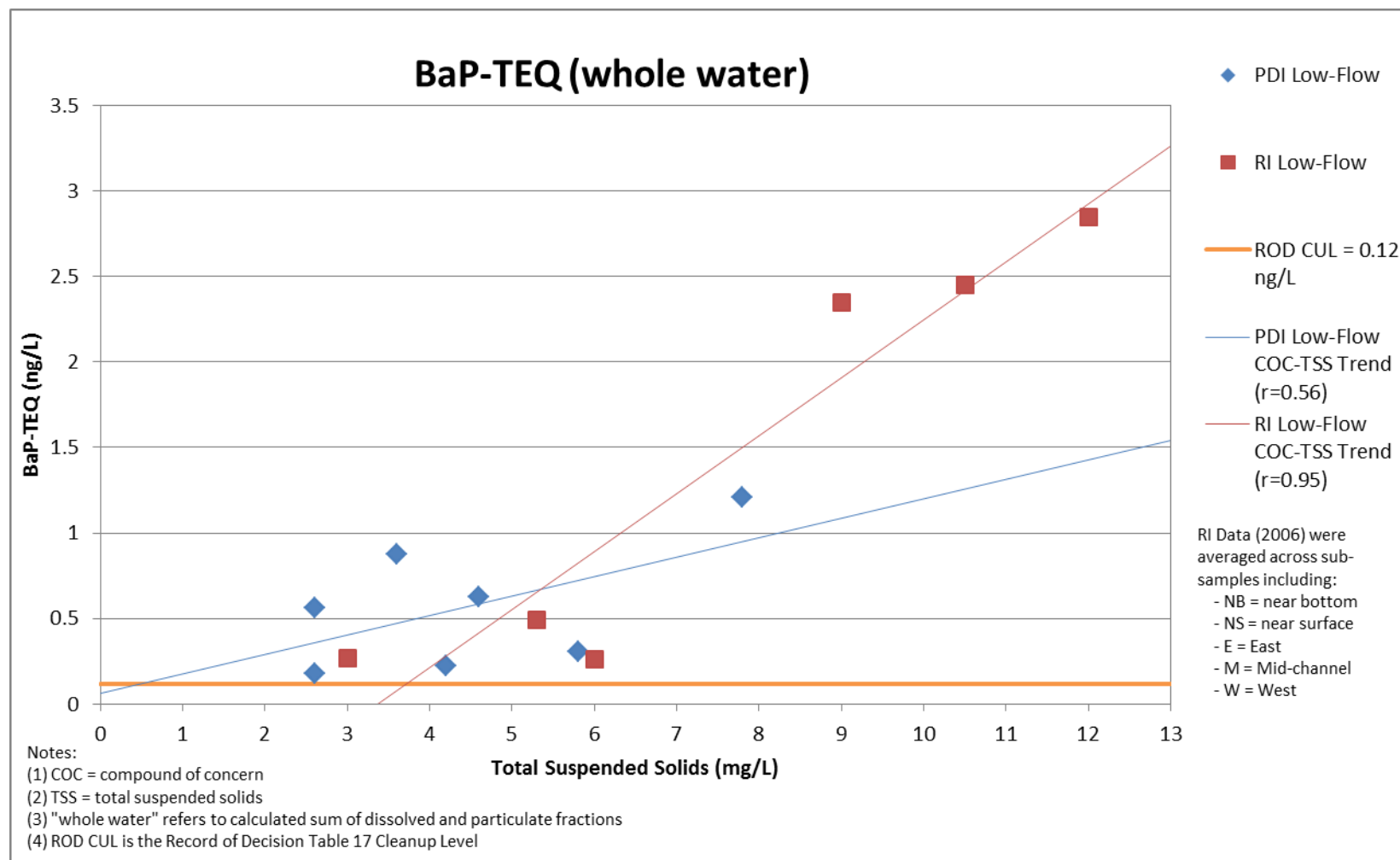Figure F-6. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI): DDx vs. Total Suspended Solids

Figure F-7. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI): TCDD-TEQ vs. Total Suspended Solids

Figure F-8. Scatter Plot: Low-Flow Events 2006 (RI) vs. 2018 (PDI): BaP-TEQ vs. Total Suspended Solids
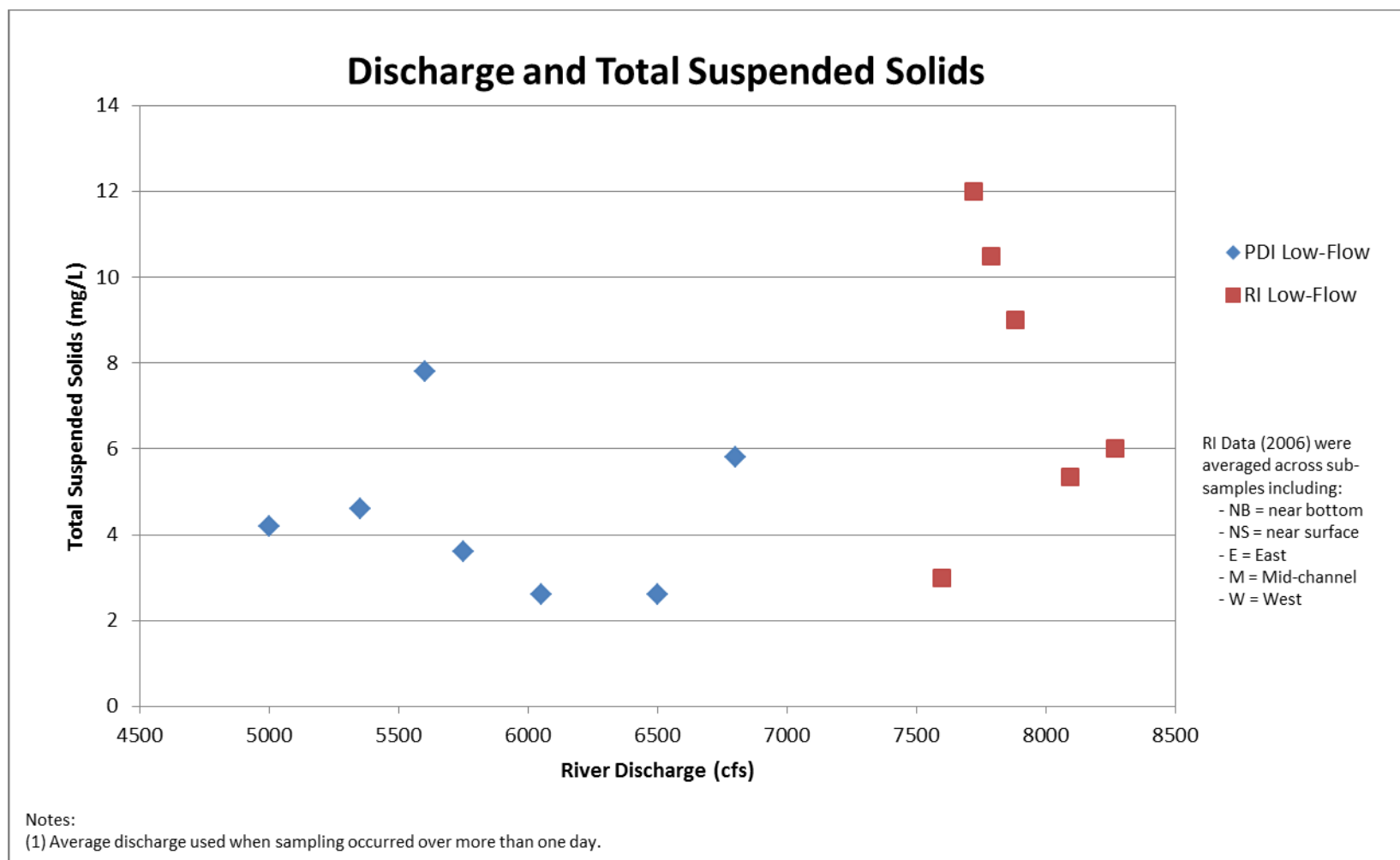
Figure F-9. Scatter Plot: Low Flow Events 2006 (RI) vs. 2018 (PDI): Discharge vs. Total Suspended Solids

EXHIBIT G

Figures Comparing COC Concentrations in Storm-Flow Events 2006 vs. 2018
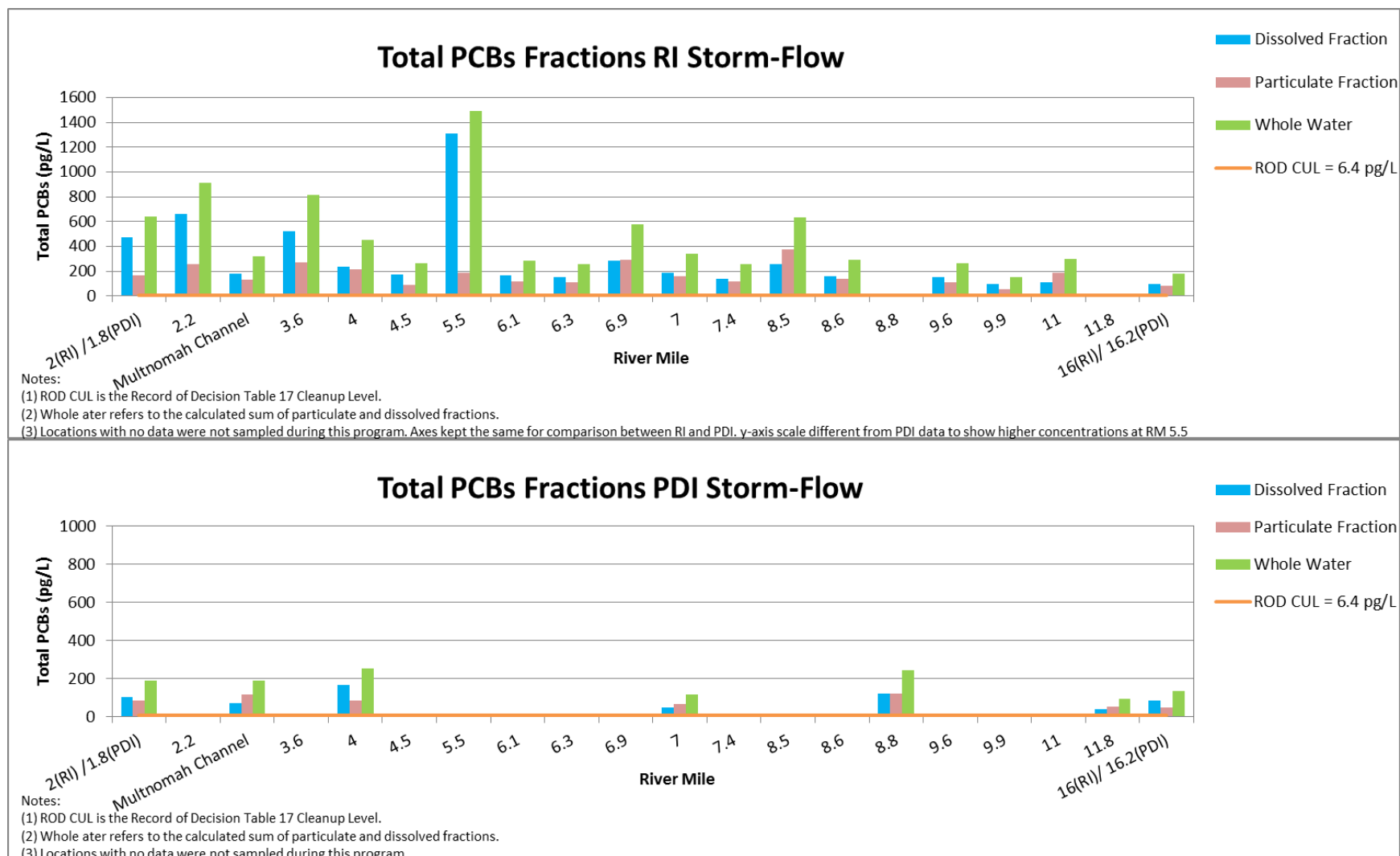
Figure G-1. Comparison of Fractions in Storm-Flow Events 2006 (RI) vs. 2018 (PDI): Total PCBs
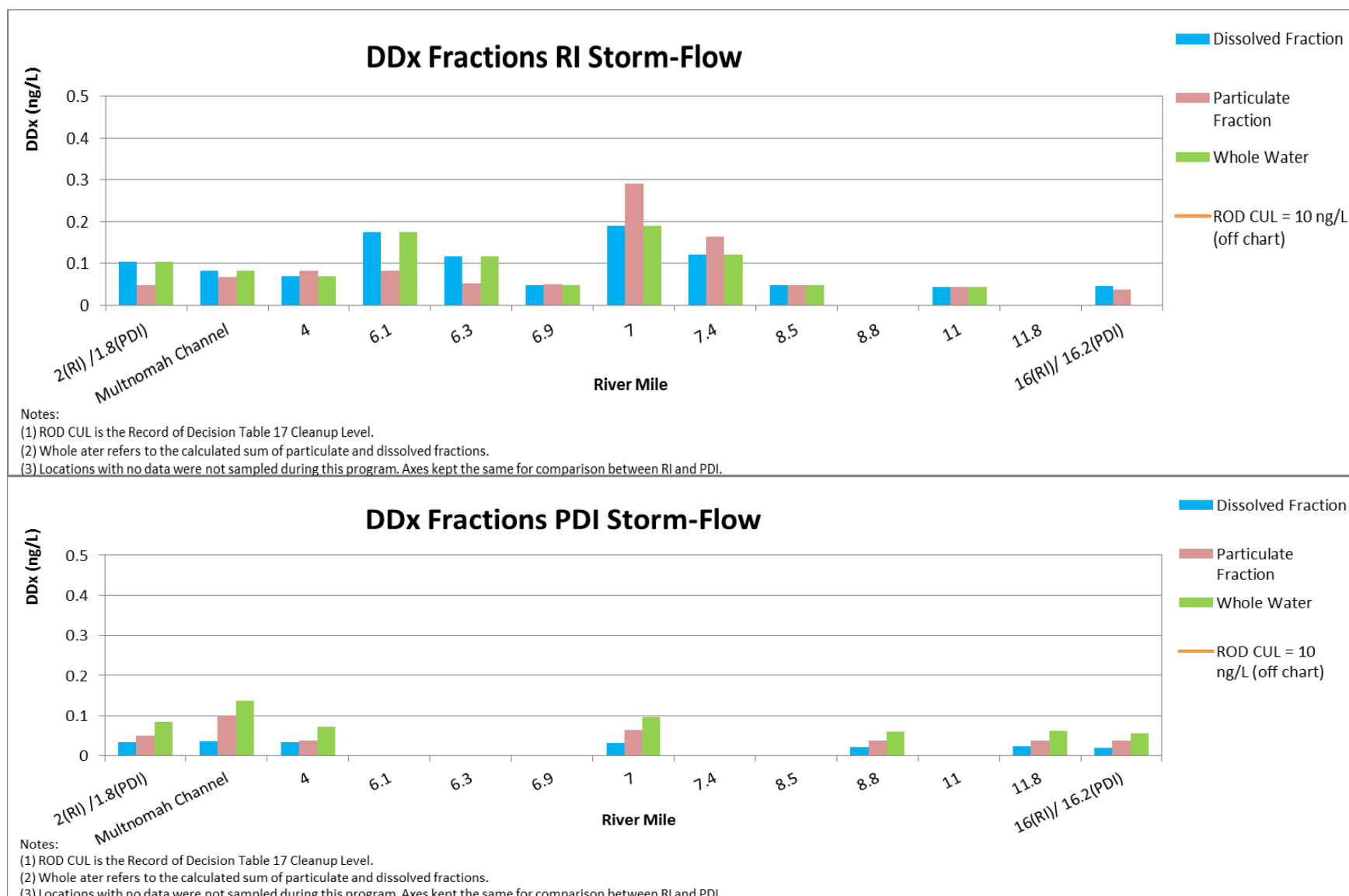
Figure G-2. Comparison of Fractions in Storm-Flow Events 2006 (RI) vs. 2018 (PDI): DDx
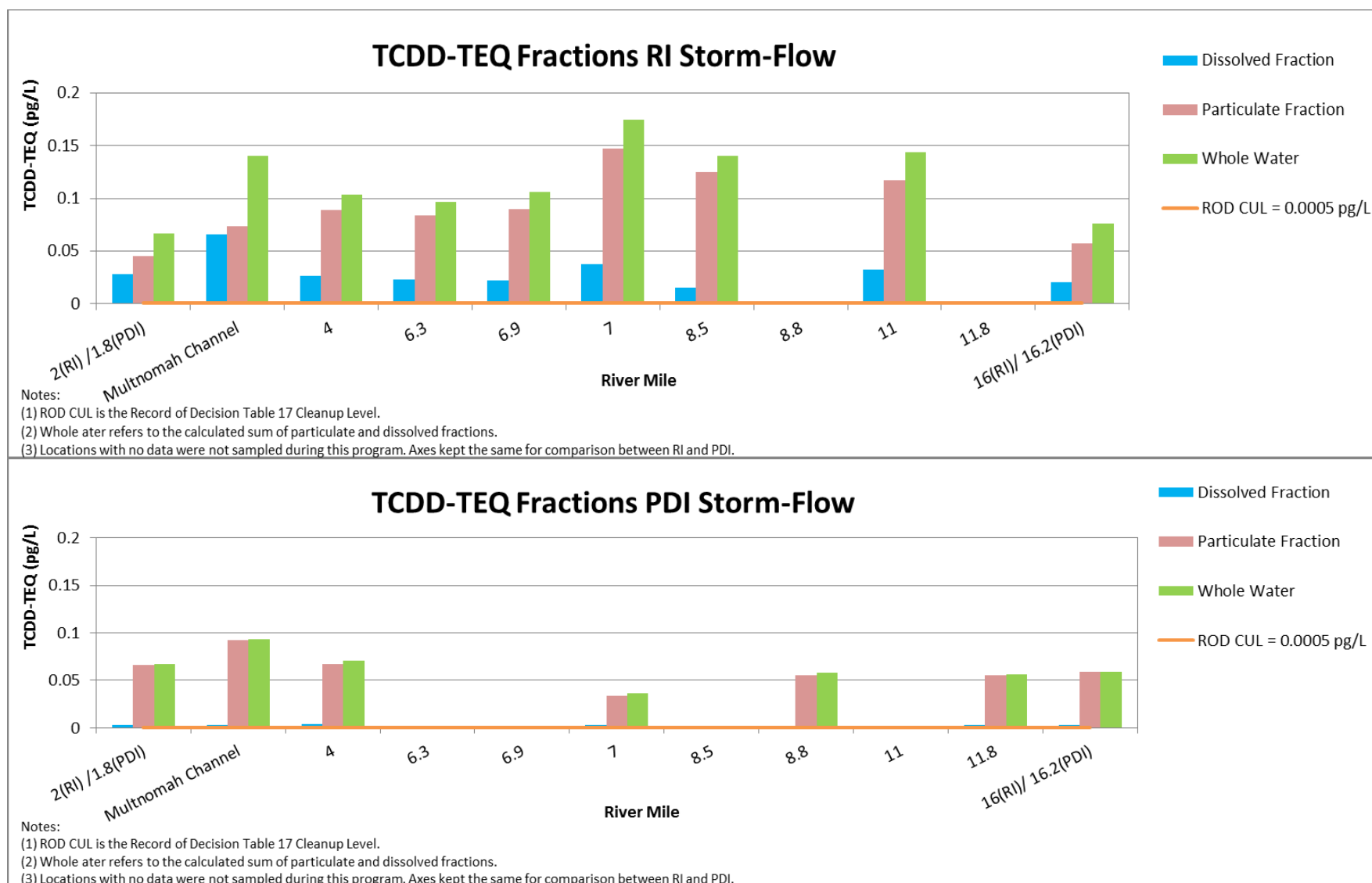
Figure G-3. Comparison of Fractions in Storm-Flow Events 2006 (RI) vs. 2018 (PDI): TCDD-TEQ

BaP-TEQ Fractions RI Storm-Flow

Legend:
- Dissolved Fraction
- Dissolved Fraction (ND)
- Particulate Fraction
- Whole Water
- ROD CUL = 0.12 ng/L

Y-axis: BaP-TEQ (ng/L)
X-axis: River Mile — 2(RI) /1.8(PDI), Multnomah Channel, 4, 6.3, 6.9, 7, 8.5, 8.8, 11, 11.8, 16(RI)/ 16.2(PDI)

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.
(4) ND = below detection limit. Full detection limit used.

BaP-TEQ Fractions PDI Storm-Flow

Legend:
- Dissolved Fraction
- Particulate Fraction
- Whole Water
- ROD CUL = 0.12 ng/L

Y-axis: BaP-TEQ (ng/L)
X-axis: River Mile — 2(RI) /1.8(PDI), Multnomah Channel, 4, 6.3, 6.9, 7, 8.5, 8.8, 11, 11.8, 16(RI)/ 16.2(PDI)

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.
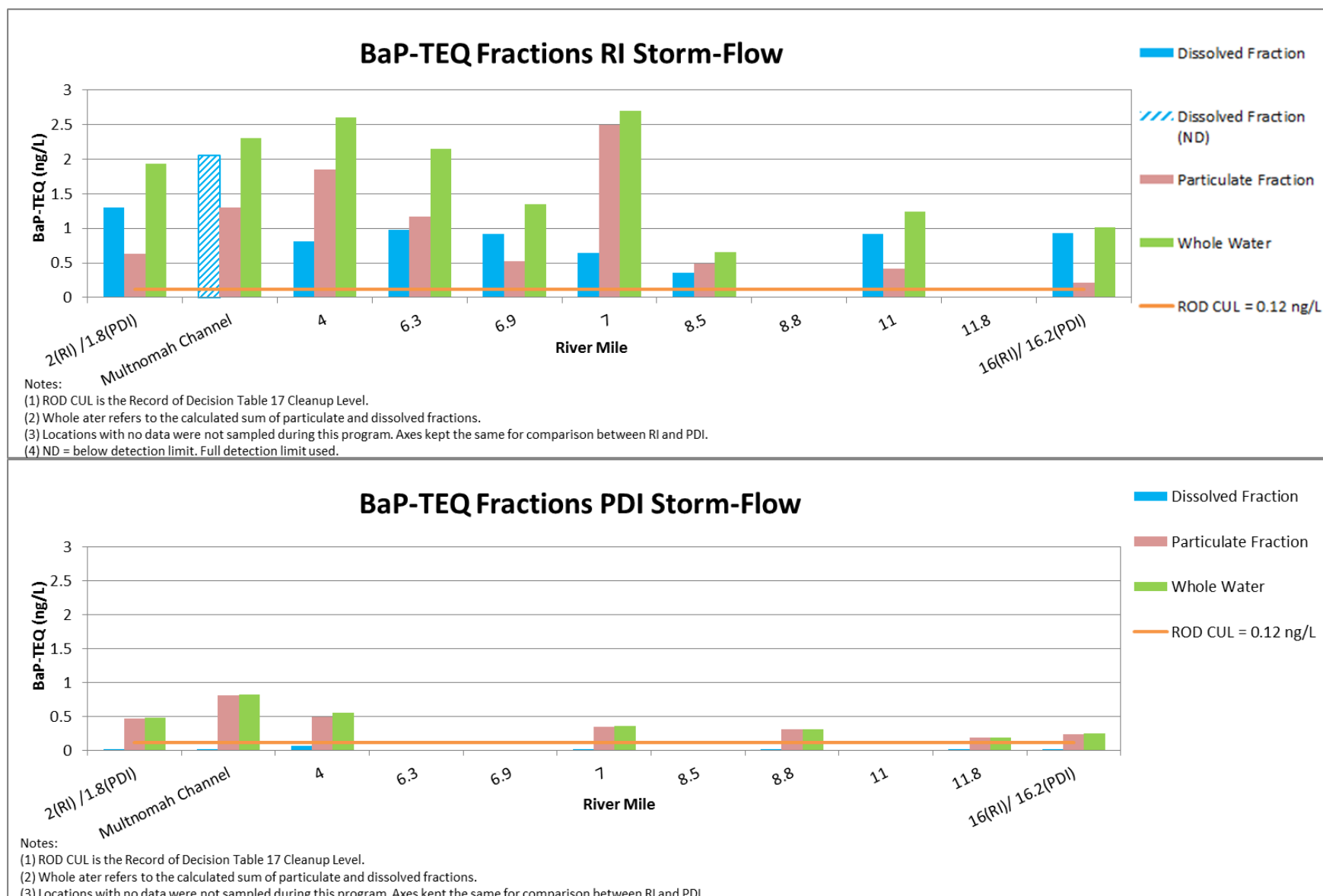
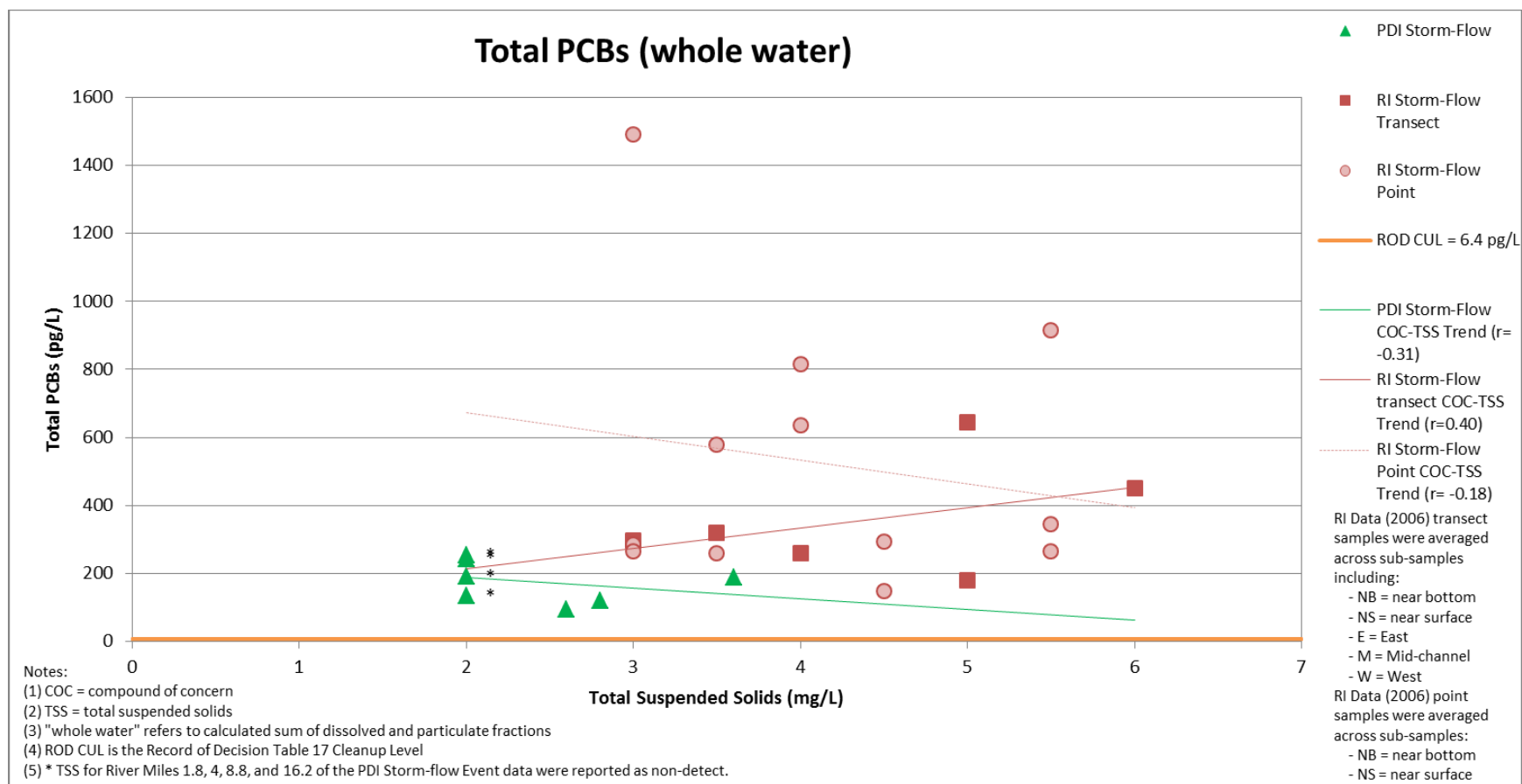Figure G-4. Comparison of Fractions in Storm-Flow Events 2006 (RI) vs. 2018 (PDI): BaP-TEQ

Figure G-5. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI): Total PCBs vs. Total Suspended Solids
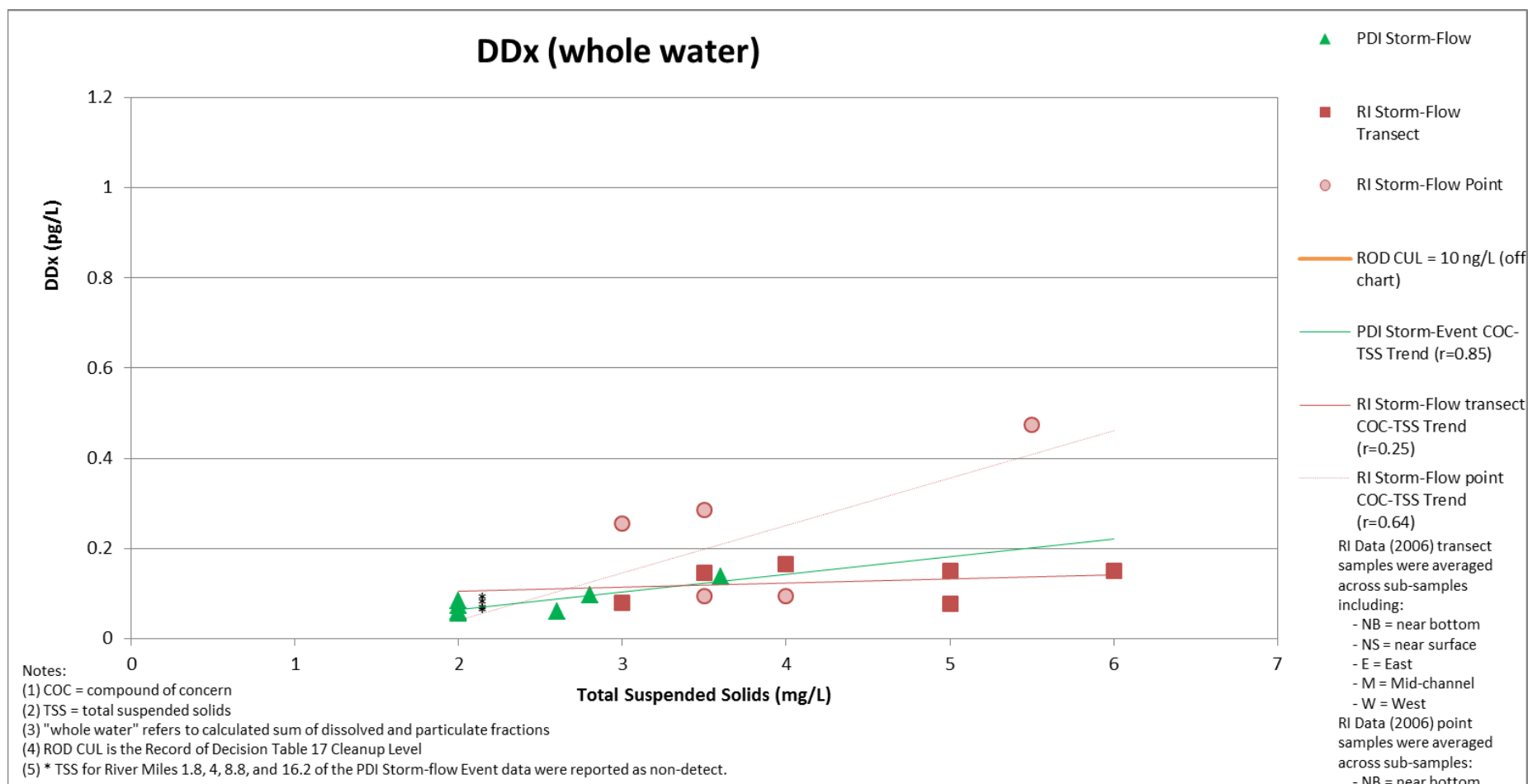
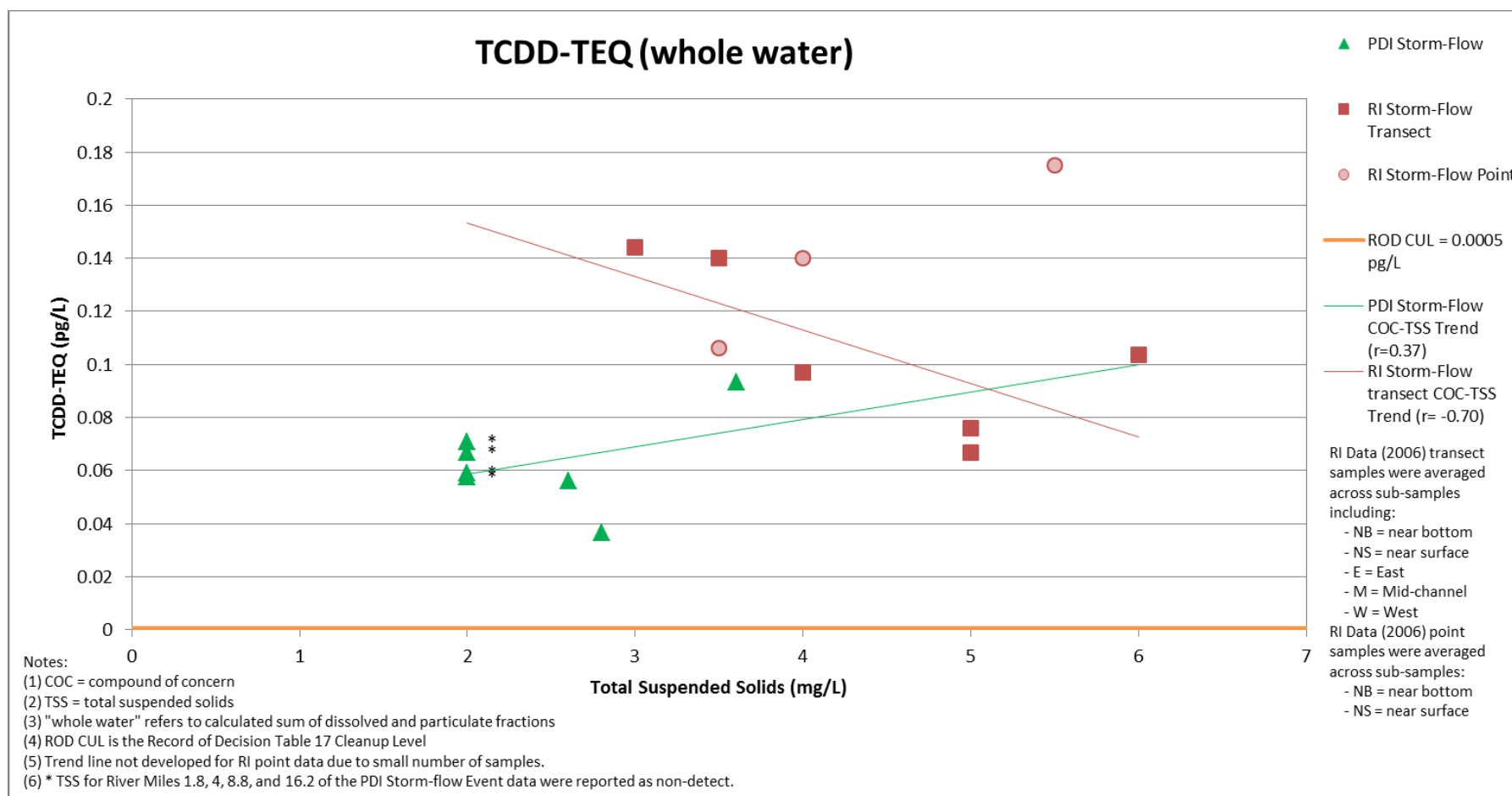Figure G-6. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI): DDx vs. Total Suspended Solids

Figure G-7. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI): TCDD-TEQ vs. Total Suspended Solids
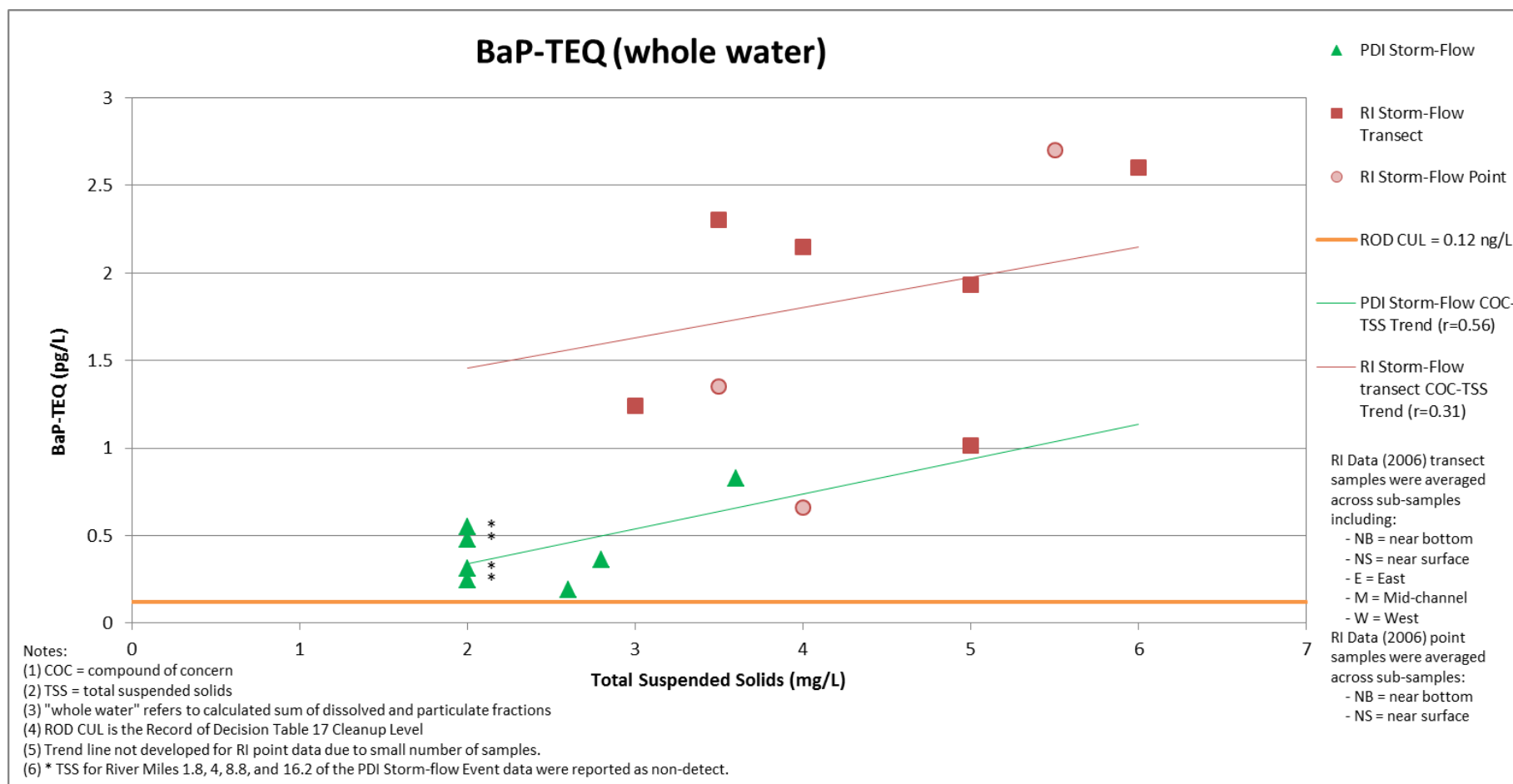
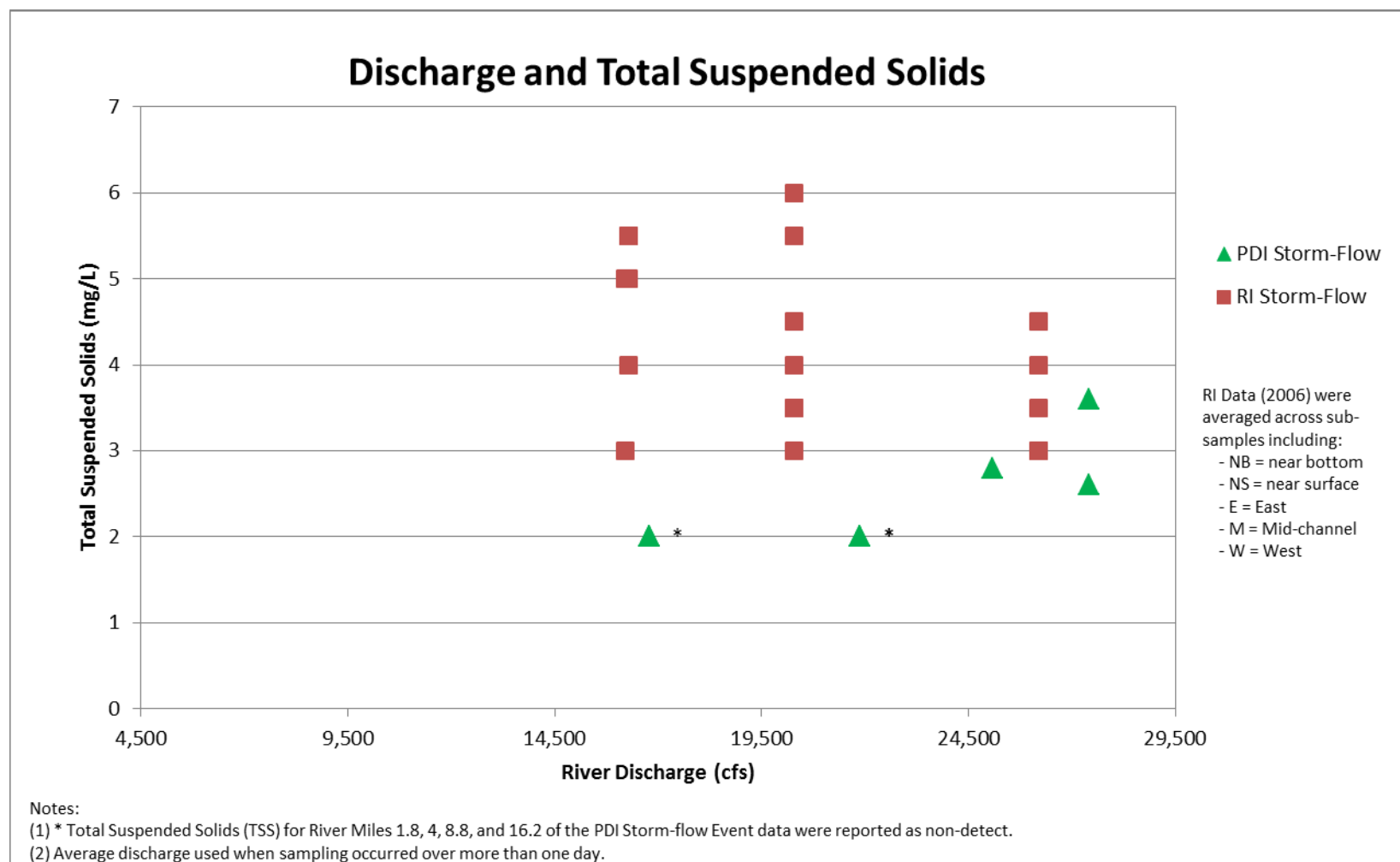Figure G-8. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI): BaP-TEQ vs. Total Suspended Solids

Figure G-9. Scatter Plot: Storm-Flow Events 2006 (RI) vs. 2018 (PDI): Discharge vs. Total Suspended Solids

EXHIBIT H

Figures Comparing COC Concentrations in High-Flow Events 2007 vs. 2019
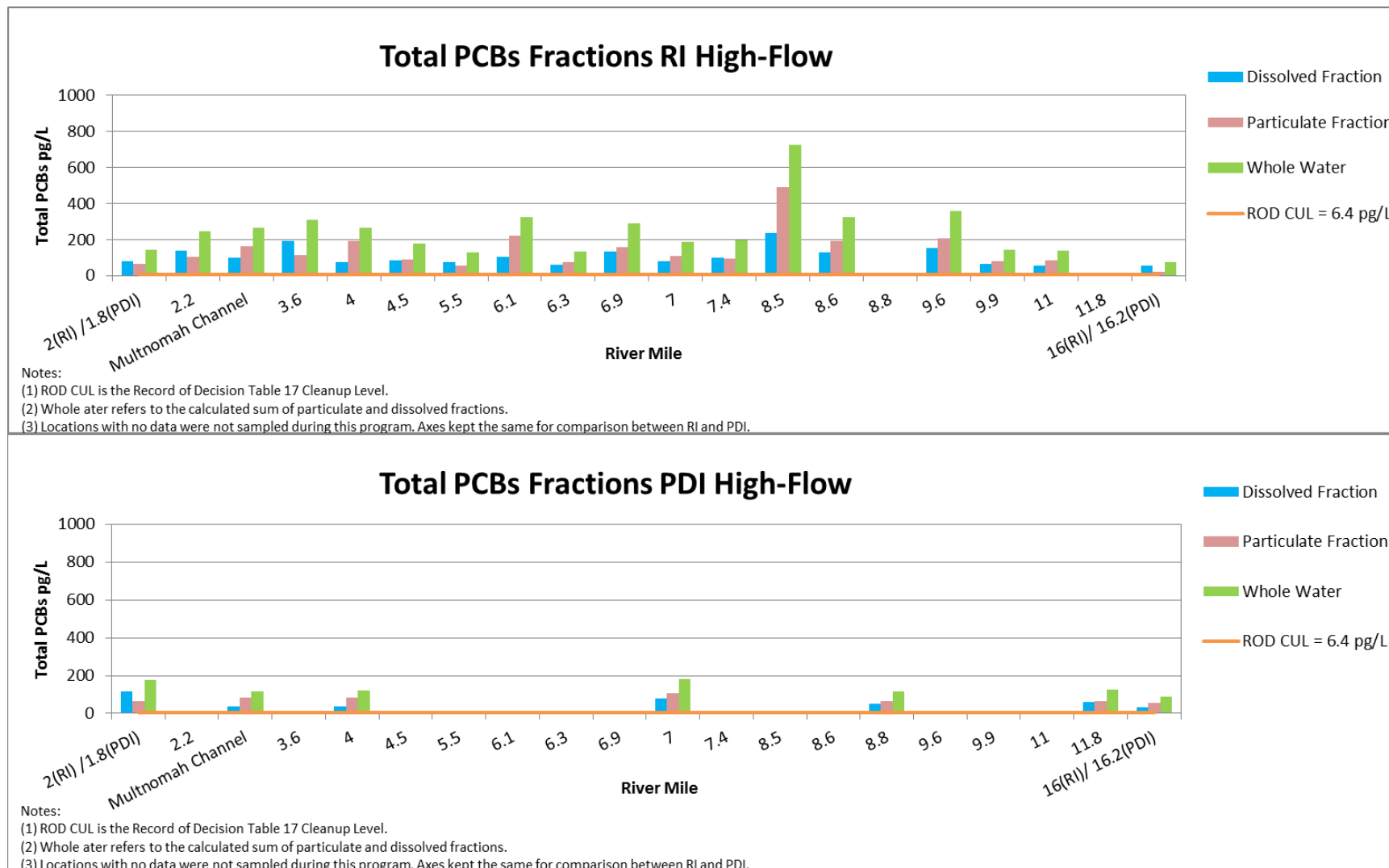
Figure H-1. Comparison of Fractions in High-Flow Events 2007 (RI) vs. 2019 (PDI): Total PCBs
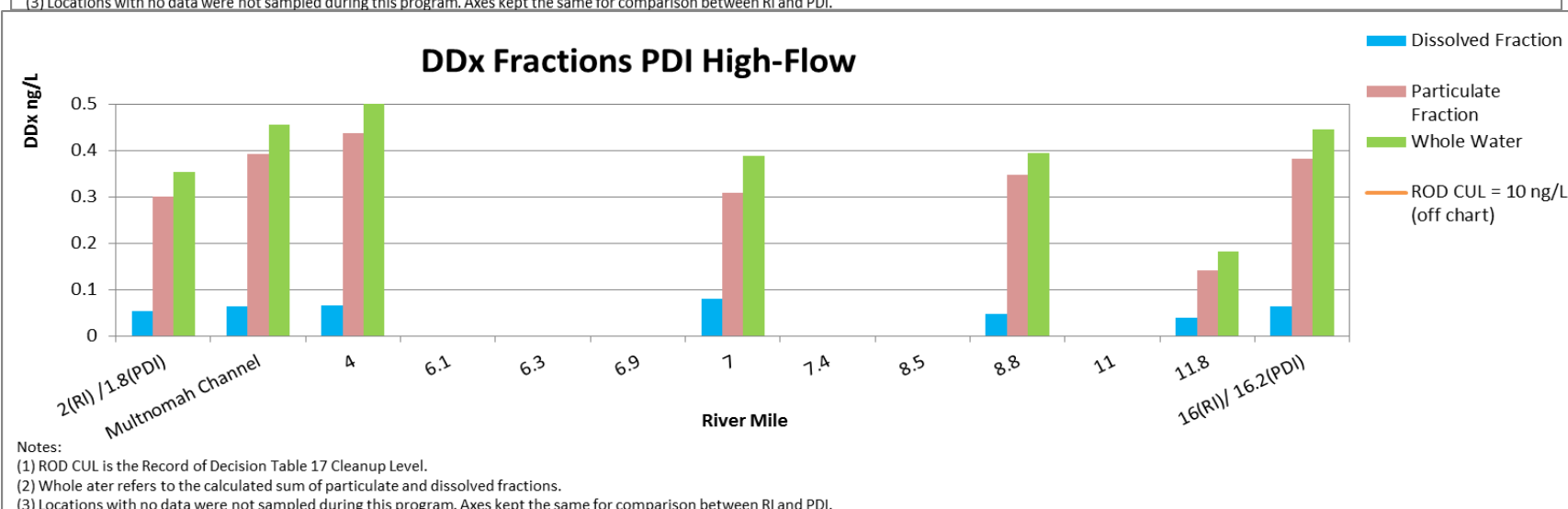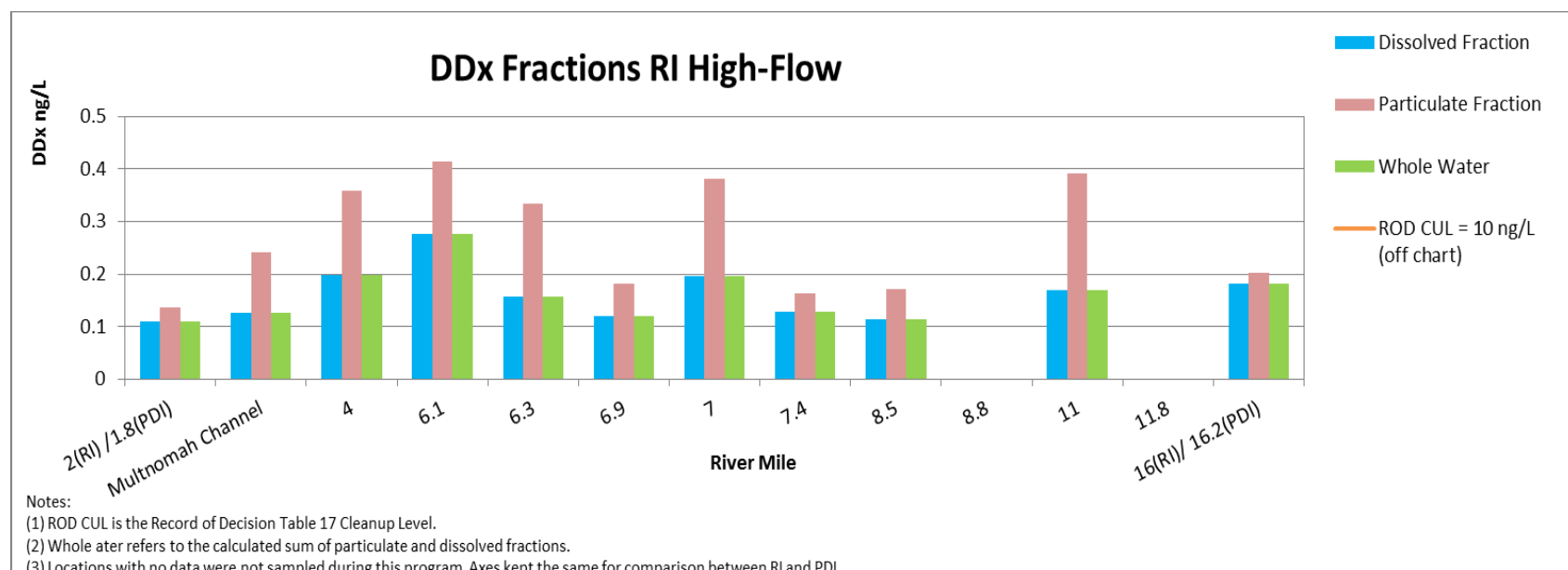
Figure H-2. Comparison of Fractions in High-Flow Events 2007 (RI) vs. 2019 (PDI): DDx
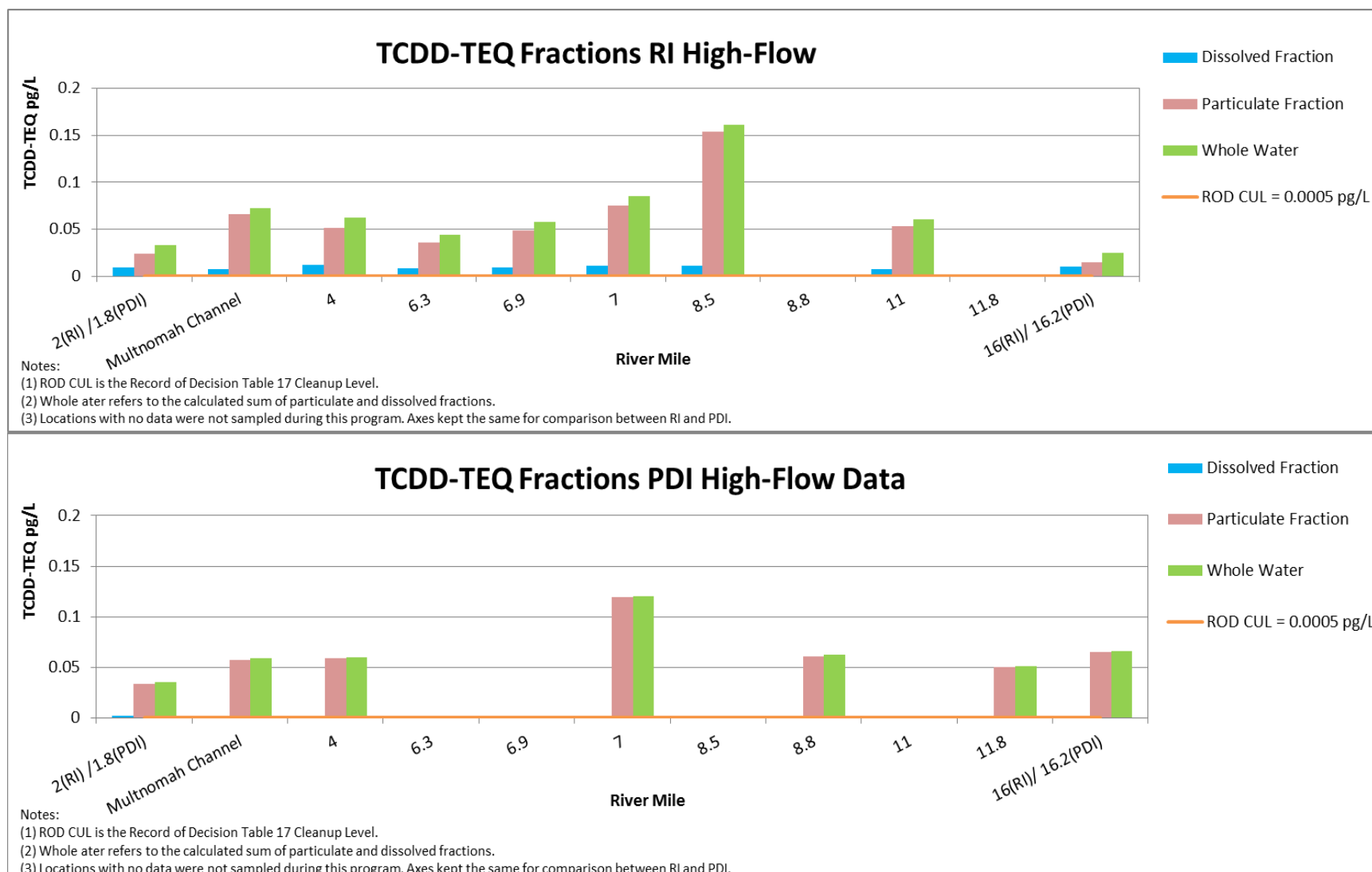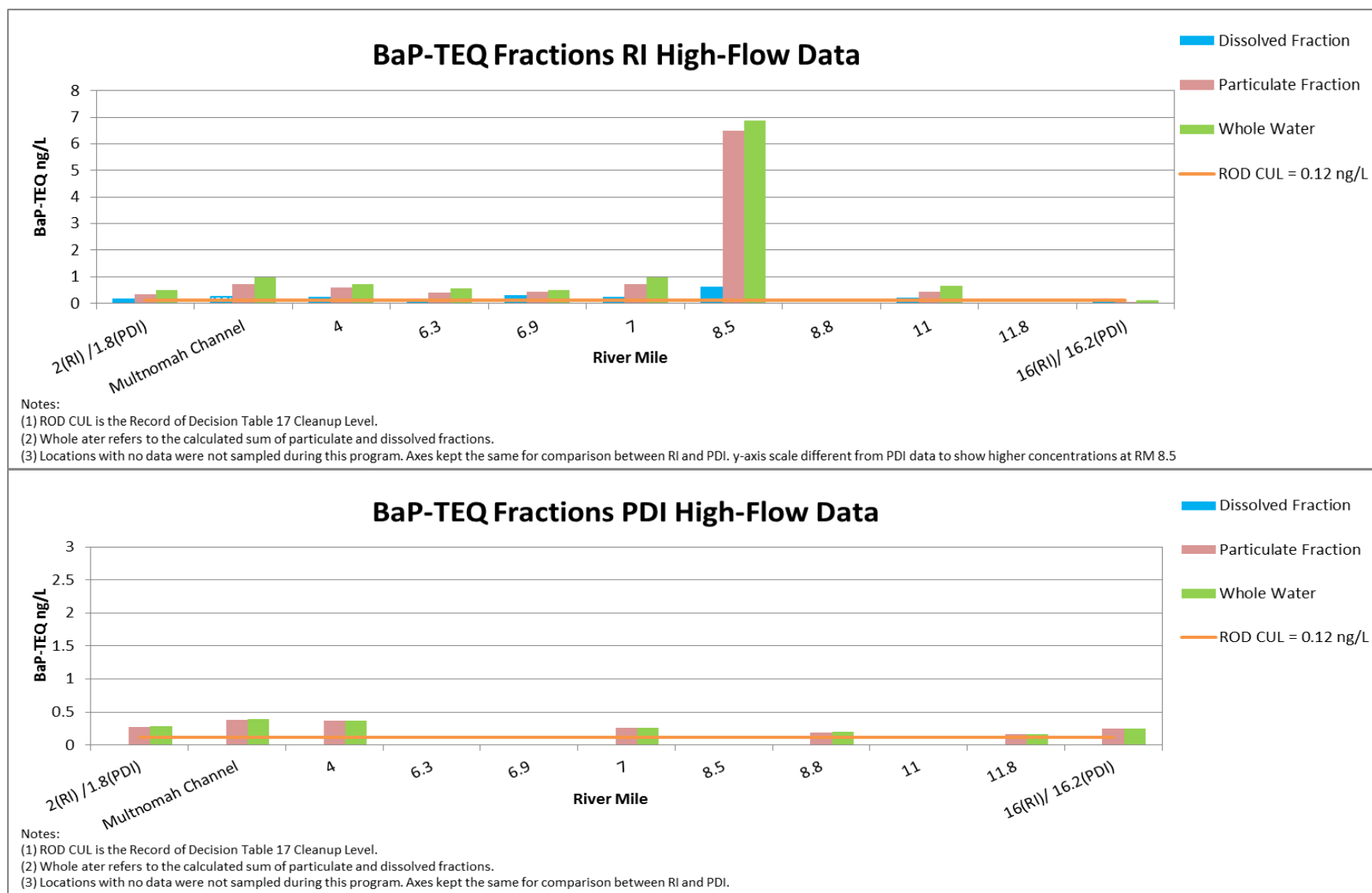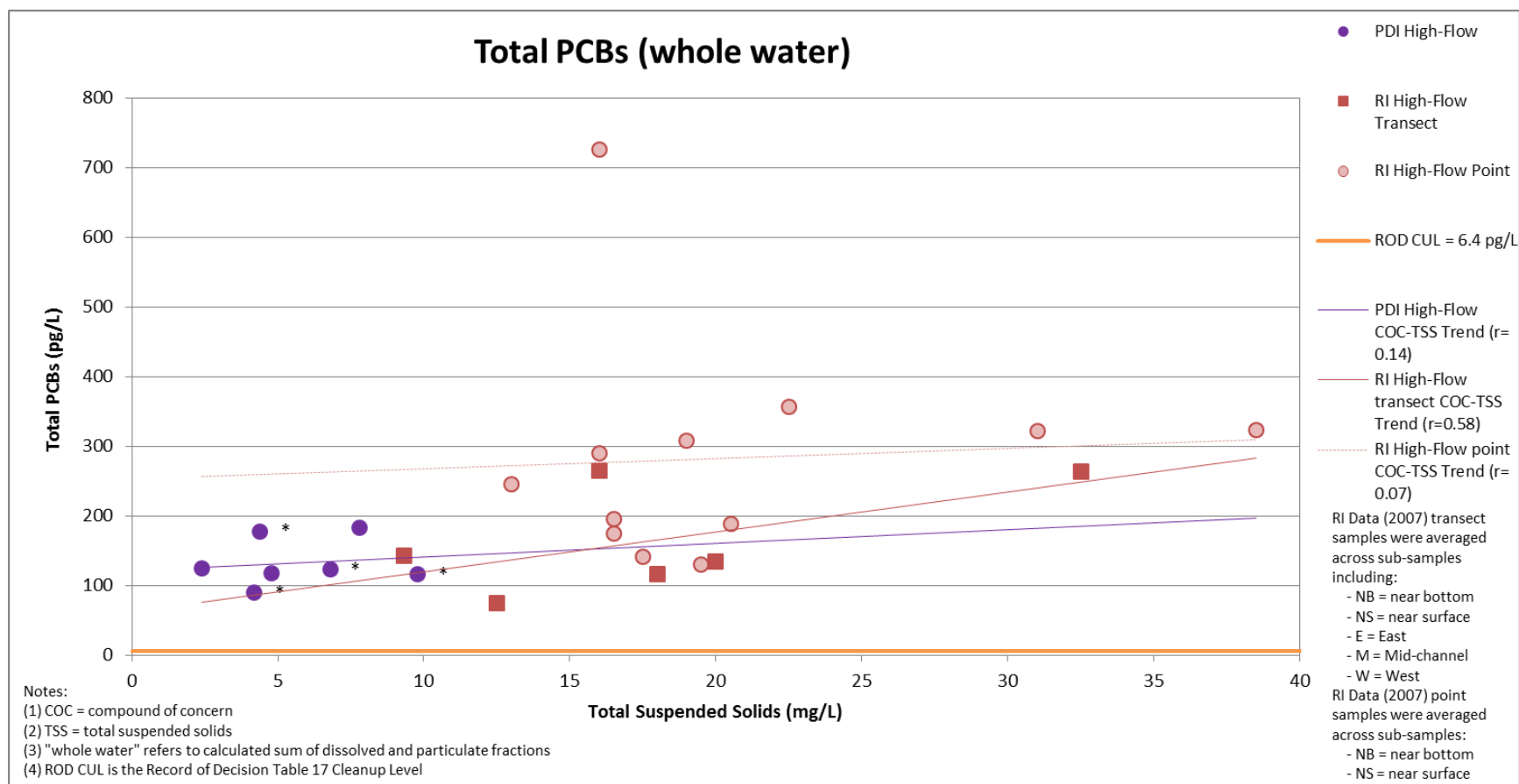
TCDD-TEQ Fractions RI High-Flow

Legend: Dissolved Fraction, Particulate Fraction, Whole Water, ROD CUL = 0.0005 pg/L

Y-axis: TCDD-TEQ pg/L

X-axis (River Mile): 2(RI) /1.8(PDI), Multnomah Channel, 4, 6.3, 6.9, 7, 8.5, 8.8, 11, 11.8, 16(RI)/ 16.2(PDI)

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.

TCDD-TEQ Fractions PDI High-Flow Data

Legend: Dissolved Fraction, Particulate Fraction, Whole Water, ROD CUL = 0.0005 pg/L

Y-axis: TCDD-TEQ pg/L

X-axis (River Mile): 2(RI) /1.8(PDI), Multnomah Channel, 4, 6.3, 6.9, 7, 8.5, 8.8, 11, 11.8, 16(RI)/ 16.2(PDI)

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.

Figure H-3. Comparison of Fractions in High-Flow Events 2007 (RI) vs. 2019 (PDI): TCDD-TEQ

BaP-TEQ Fractions RI High-Flow Data

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI. y-axis scale different from PDI data to show higher concentrations at RM 8.5

BaP-TEQ Fractions PDI High-Flow Data

Notes:
(1) ROD CUL is the Record of Decision Table 17 Cleanup Level.
(2) Whole ater refers to the calculated sum of particulate and dissolved fractions.
(3) Locations with no data were not sampled during this program. Axes kept the same for comparison between RI and PDI.

Figure H-4. Comparison of Fractions in High-Flow Events 2007 (RI) vs. 2019 (PDI): BaP-TEQ

Figure H-5. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI): Total PCBs vs. Total Suspended Solids
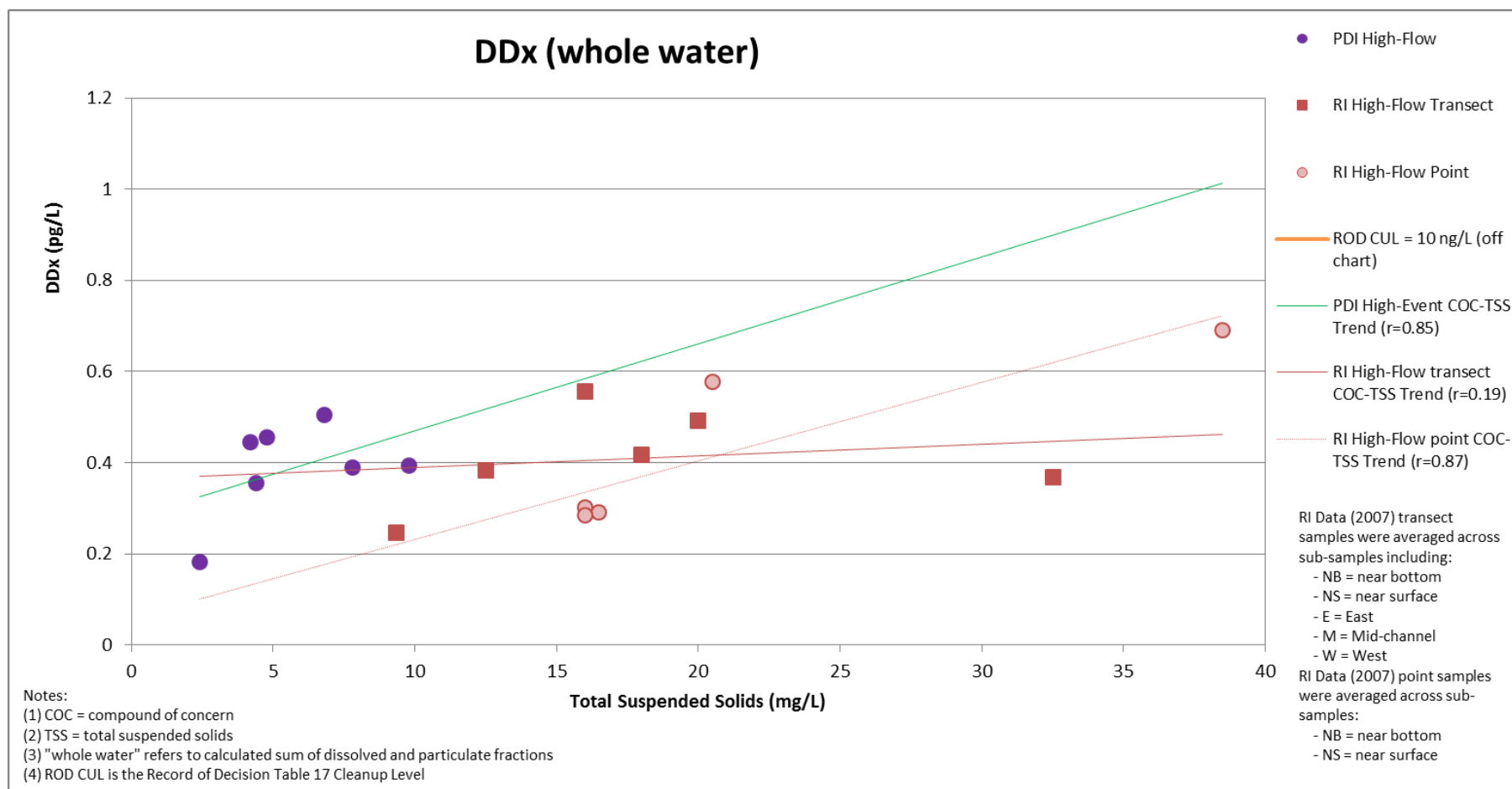
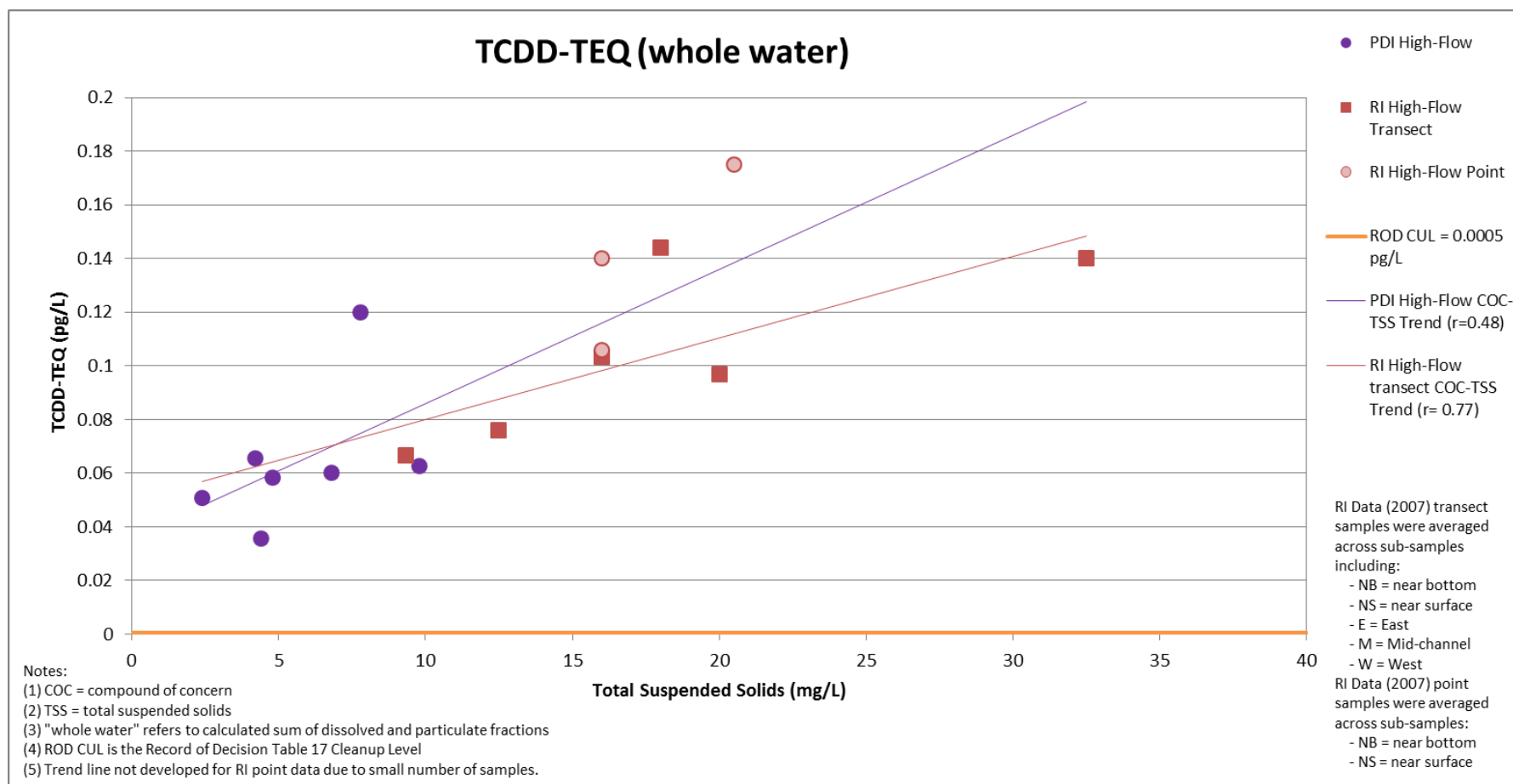Figure H-6. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI): DDx vs. Total Suspended Solids

Figure H-7. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI): TCDD-TEQ vs. Total Suspended Solids
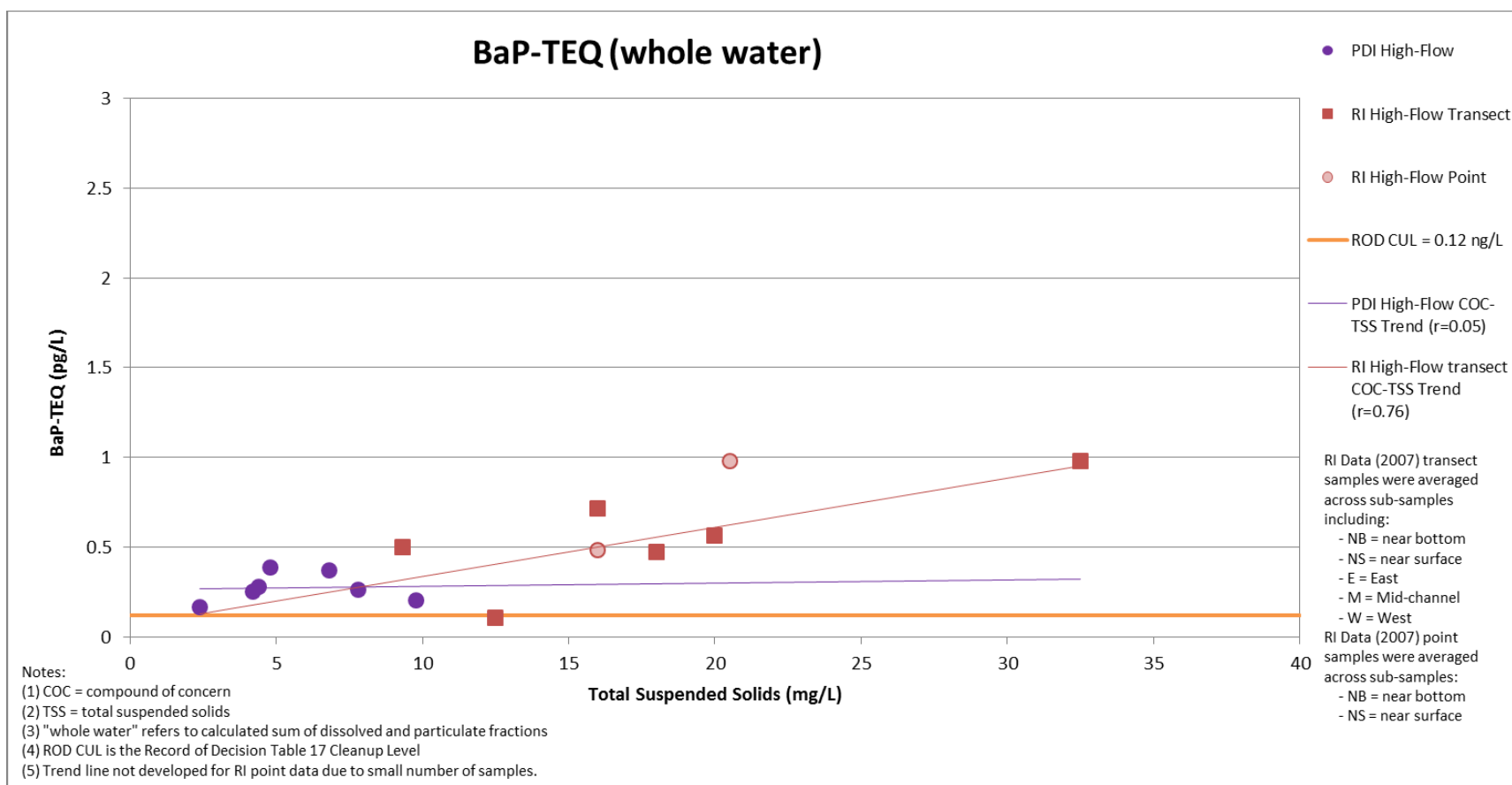
Figure H-8. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI): BaP-TEQ vs. Total Suspended Solids
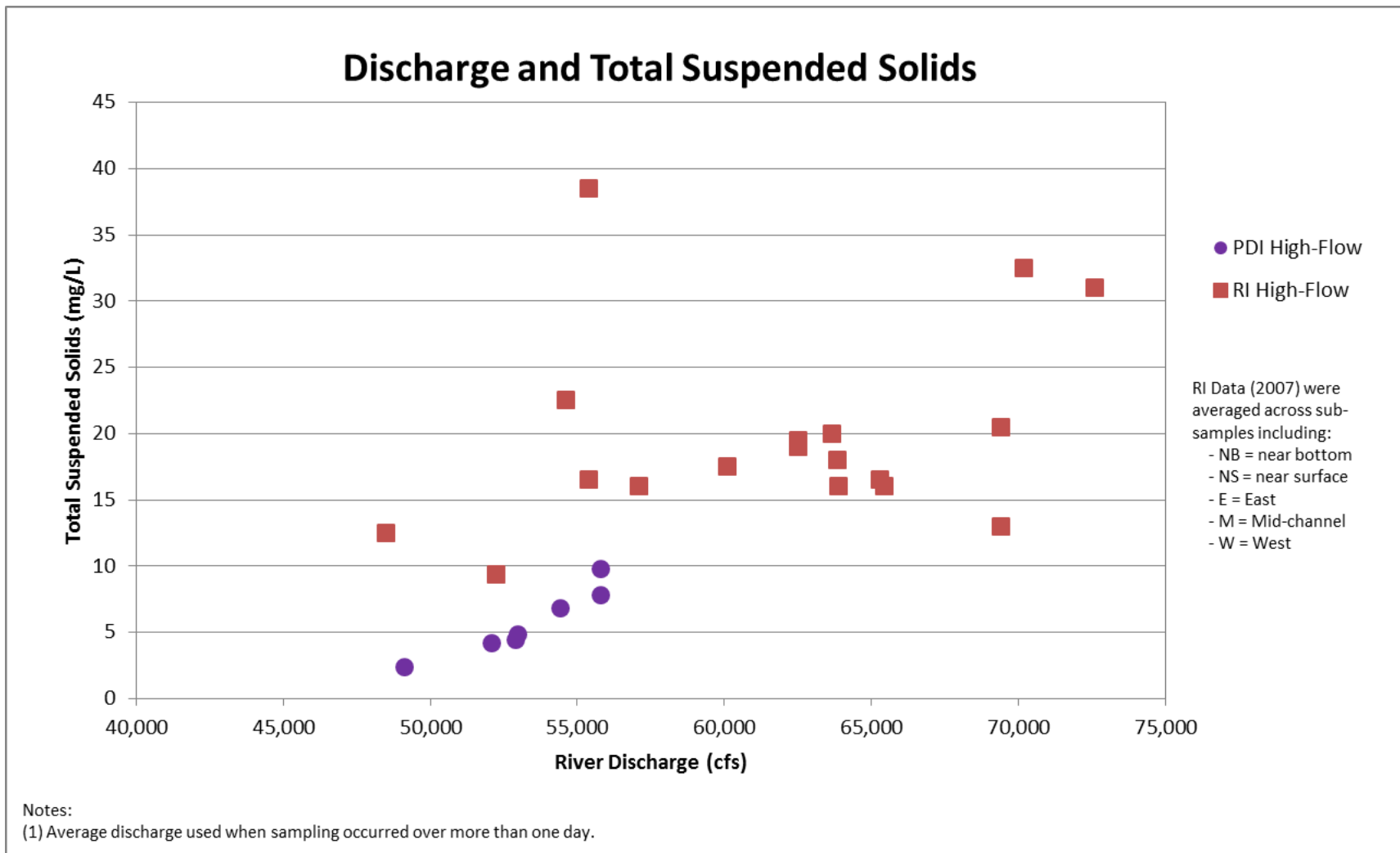
Figure H-9. Scatter Plot: High-Flow Events 2007 (RI) vs. 2019 (PDI): Discharge vs. Total Suspended Solids

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